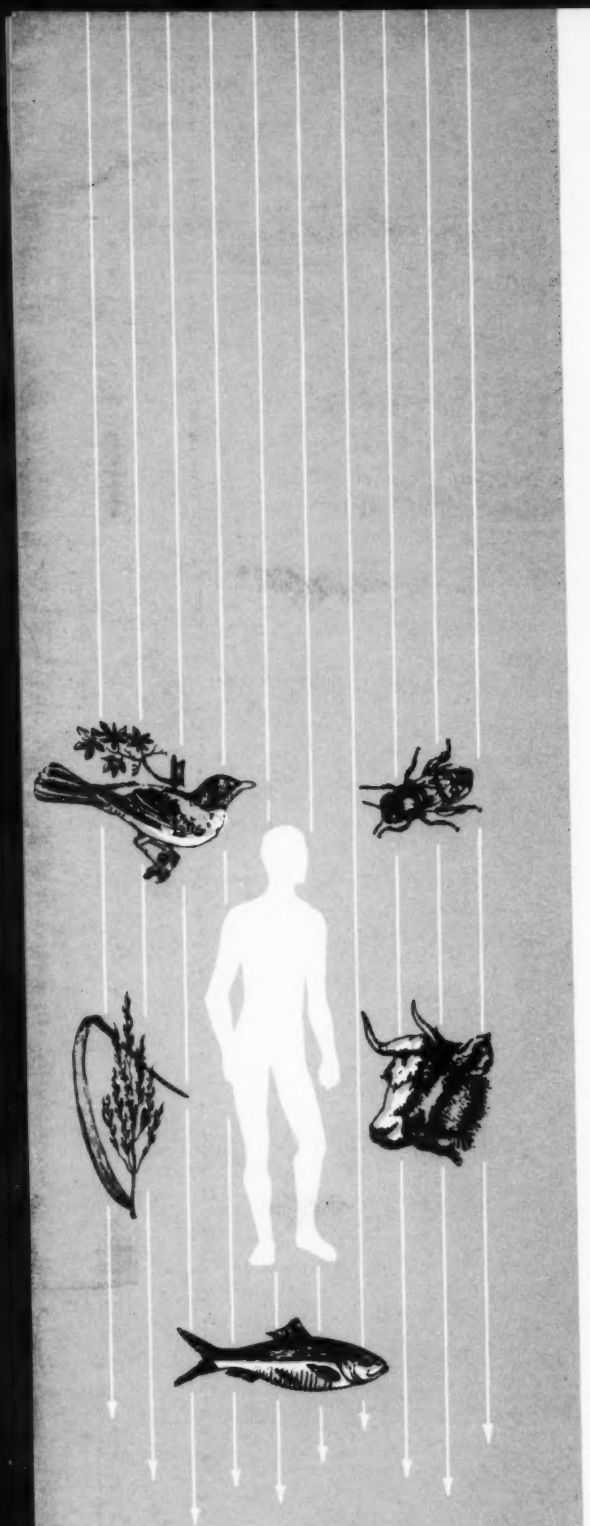

PESTICIDES MONITORING JOURNAL

MARCH 1977

VOLUME 10 NUMBER 4

PEMJAA 10(4)121-180 (1977)

ANNUAL INDEX

VOL. 10, JUNE 1976-MARCH 1977

FEDERAL WORKING GROUP ON PEST MANAGEMENT
(RESPONSIBLE TO THE COUNCIL ON ENVIRONMENTAL QUALITY)

FEDERAL WORKING GROUP ON PEST MANAGEMENT*

Department of Health, Education, and Welfare
J. V. Smith, *Chairman*
J. R. Wessel

Department of the Interior
B. Blanchard
R. F. Reiske
W. H. Stickel

Department of State
E. H. Smith

Department of Commerce
J. Lewis, *Vice-Chairman*
T. C. Carver
J. B. Cox
W. V. Hartwell

Department of Labor
J. P. O'Neill

Department of Agriculture
J. M. Barnes
T. G. Darling
F. W. Honing
R. C. Riley
K. C. Walker

Department of Defense
J. G. McWilliams
W. W. Barrett
W. W. Young

Department of Transportation
W. F. Mitchell

Environmental Protection Agency
W. C. Holmberg
P. H. Gray, Jr.

OBSERVERS

Council on Environmental Quality
W. Muir

National Science Foundation
E. J. Burger, Jr.

MONITORING PANEL

Department of Agriculture
J. H. Caro, *Agricultural Research Service*
E. L. Cox, *Agricultural Research Service*
L. Heffner, *Extension Service*
F. W. Honing, *Forest Service*
A. R. Isensee, *Agricultural Research Service*
P. C. Kearney, *Agricultural Research Service*
M. S. Schechter, *Agricultural Research Service*
H. M. Trabosh, *Animal and Plant Health Inspection Service*
R. L. Williamson, *Animal and Plant Health Inspection Service*

Department of Health, Education, and Welfare
P. F. Corneliussen, *Food and Drug Administration*
J. R. Wessel, *Food and Drug Administration*

Department of the Interior
C. R. Walker, *Fish and Wildlife Service*
H. R. Feltz, *Geological Survey*
F. P. Kapinos, *Geological Survey*

Department of Commerce
T. C. Carver, *National Marine Fisheries Service*
W. V. Hartwell, *Office of Environmental Affairs*

Department of Defense
C. S. Bulger, *Department of the Army*
C. C. Roan, *Department of the Army*
J. H. Vinopal, *Department of the Army*

Environmental Protection Agency
P. A. Butler, *National Environmental Research Laboratory, Fla.*
A. E. Carey, *Office of Pesticide Programs*
R. G. Heath, *Office of Pesticide Programs*
F. W. Kutz, *Office of Pesticide Programs*
C. I. Plost, *Office of Research and Development*
J. E. Pulliam, *Office of Pesticide Programs*
G. E. Walsh, *National Environmental Research Laboratory, Fla.*
G. B. Wiersma, *National Environmental Research Center, Nev.*
D. L. Worf, *National Environmental Research Center, N.C.*

National Science Foundation
J. T. Callahan III, *Ecosystem Studies*

Tennessee Valley Authority
W. W. Barnes, *Division of Environmental Planning*
J. C. Cooney, *Division of Environmental Planning*

* Responsible to the Council on Environmental Quality.

The *Pesticides Monitoring Journal* is published quarterly under the auspices of the Federal Working Group on Pest Management (responsible to the Council on Environmental Quality) and its Monitoring Panel as a source of information on pesticide levels relative to humans and their environment.

The Working Group is comprised of representatives of the U.S. Departments of Agriculture; Commerce; Defense; the Interior; Health, Education, and Welfare; State; Transportation; and Labor; and the Environmental Protection Agency.

The Monitoring Panel consists of representatives of the Agricultural Research Service, Animal and Plant Health Inspection Service, Extension Service, Forest Service, Department of Defense, Fish and Wildlife Service, Geological Survey, Food and Drug Administration, Environmental Protection Agency, National Marine Fisheries Service, National Science Foundation, and Tennessee Valley Authority.

The *Pesticides Monitoring Journal* is published by the Technical Services Division, Office of Pesticide Programs, U.S. Environmental Protection Agency.

Pesticide monitoring activities of the Federal Government, particularly in those agencies represented on the Monitoring Panel which participate in operation of the national pesticides monitoring network, are expected to be the principal sources of data and articles. However, pertinent data in summarized form, together with discussions, are invited from both Federal and non-Federal sources, including those associated with State and community monitoring programs, universities, hospitals, and nongovernmental research institutions, both domestic and foreign. Results of studies in which monitoring data play a major or minor role or serve as support for research investigation also are welcome; however, the Journal is not intended as a primary medium for the publication of basic research. Publication of scientific data, general information, trade names, and commercial sources in the *Pesticides Monitoring Journal* does not represent endorsement by any Federal agency.

Manuscripts received for publication are reviewed by an Editorial Advisory Board established by the Monitoring Panel. Authors are given the benefit of review comments prior to publication. For further information on Journal scope and manuscript preparation, see Information for Contributors at the back of this issue.

Editorial Advisory Board members are:

John R. Wessel, *Food and Drug Administration, Chairman*
Robert L. Williamson, *Animal and Plant Health Inspection Service*
Anne R. Yobs, *Center for Disease Control*
William F. Durham, *Environmental Protection Agency*
Gerald E. Walsh, *Environmental Protection Agency*
G. Bruce Wiersma, *Environmental Protection Agency*
William H. Stickel, *Fish and Wildlife Service*
Milton S. Schechter, *Agricultural Research Service*
Herman R. Feltz, *Geological Survey*

Address correspondence to:

Paul Fuschini (WH-569)
Editorial Manager
Pesticides Monitoring Journal
U. S. Environmental Protection Agency
Washington, D.C. 20460

Editor
Martha Finan

CONTENTS

Volume 10 March 1977 Number 4

Page

PESTICIDES IN PEOPLE

Organochlorine compounds in human blood plasma and milk ____ 121
Z. W. Polishuk, M. Ron, M. Wassermann, Simi Cucos, Dora Wassermann, and C. Lemesch

Insecticide residues in human milk from Arkansas and Mississippi, 1973-74 ____ 130
Sandra C. Strassman and Frederick W. Kutz

RESIDUES IN FOOD AND FEED

Pesticide residues in total diet samples (X) ____ 134
D. D. Manske and R. D. Johnson

RESIDUES IN FISH, WILDLIFE, AND ESTUARIES

Organochlorine pesticide and polychlorinated biphenyl residues in selected fauna from a New Jersey salt marsh—1967 vs. 1973 ____ 149
Erwin E. Klaas and Andre A. Belisle

GENERAL

Monitoring agricultural insecticides in the cooperative cotton pest management program in Arizona, 1971—first-year study ____ 159
Donald W. Woodham, Hugh F. Robinson, Robert G. Reeves, Charles A. Bond, and Harry Richardson

BRIEF

DDT residues in air in the Mississippi Delta, 1975 ____ 168
Robert D. Arthur, Jimmie D. Cain, and Ben F. Barrentine

APPENDIX

Chemical names of compounds discussed in this issue ____ 169

ACKNOWLEDGMENT ____ 170

ANNUAL INDEX (Volume 10, June 1976—March 1977)

Preface ____ 171
Subject Index ____ 172
Author Index ____ 177

Information for contributors ____ 179

PESTICIDES IN PEOPLE

Organochlorine Compounds in Human Blood Plasma and Milk[1]

Z. W. Polishuk,[2] M. Ron,[3] M. Wassermann,[4] Simi Cucos,[4] Dora Wassermann,[4] and C. Lemesch[4]

ABSTRACT

Organochlorine insecticides and polychlorinated biphenyls (PCB's) were assessed in human blood plasma and milk collected from Israeli mothers 2-4 days after childbirth during 1975.

The concentration of total DDT (ΣDDT) was similar in whole plasma and milk (74 ppb versus 72 ppb) and higher in plasma-extracted lipids than in milk-extracted lipids: 15.12 ppm versus 5.77 ppm.

Levels of γ-BHC, dieldrin, and heptachlor epoxide were higher in whole plasma and plasma-extracted lipids than in whole milk or in milk-extracted lipids.

PCB's had similar concentrations in extracted lipids of plasma and milk but were significantly higher in whole milk than in whole plasma.

Higher percentages of organochlorine insecticides and PCB's were excreted in milk from mothers between 20 and 29 than between 30 and 39, although the younger group had lower levels of these compounds in plasma.

Overweight women excreted lower quantities of organochlorine insecticides and PCB's than did women of normal weight.

Introduction

A broad spectrum of environmental toxic compounds has been reported in human milk. The accumulation of xenobiotics may reach levels dangerous to breast-fed babies. Skin disorders and some deaths occurred in children of nursing mothers who had eaten hexachlorobenzene-treated wheat seed in Turkey in 1956 (*38*). Yusho disease in Japan, associated with accidental ingestion of polychlorinated biphenyls (PCB's), had such symptoms as stillbirth or intrauterine growth retardation, abnormal pigment and desquamation of skin and mucous membranes, early appearance of teeth, calcification of the skull, exophthalmos and gingival hypertrophy (*58*). Monkeys which were experimentally given PCB's showed reduced fertility, and pregnancies which produced small infants (*4*). Mercury and lead have also been transmitted in milk at levels which can be toxic to babies (*38*). In 8 of 101 milk samples, the concentration of mercury exceeded the permissible level of 0.010 ppm. All 8 donors had helped to prepare grain for sowing during pregnancy (*32*).

Organochlorine insecticides have reached unusually high levels in mother's milk in Central America and Japan. In areas of Guatemala where cotton was intensively cultivated, DDT reached 4.07 ppm in whole milk, compared with 1.83 ppm and 2.15 ppm outside the cotton-growing regions (*59*). Safety precautions seem to be very poor among small farmers using insecticides (*16*). High levels of organochlorines were also found in milk from areas subjected to malaria control programs (*29*). In Guatemala the levels of DDT in human milk proved to be 25-30 times the average level found in the United States, England, and Sweden, and hundreds of times higher than the maximum permissible level established by WHO for cow's milk (*44*). In Japan, β-BHC proved to be the most hazardous organochlorine insecticide. In 1971 the average 6-month-old baby in Nagasaki ingested an average of 1.2288 mg BHC (*48*). In other prefectures, β-BHC in whole milk reached levels up to hundreds of ppb. Beta-BHC had been used extensively as a pesticide in ricefields of Japan. The rice straw served as cow feed. High values of pesticides were found in cow's milk from the western region of Japan where these compounds were used in large amounts. In a survey conducted in 1970-71 in Aichi, Japan, total BHC in cow's milk ranged from 10 to 1,100 ppb (*55*).

1 This investigation supported in part by a grant from the Ministry of Health, Jerusalem, and a research agreement from the United Nations—World Health Organization, International Agency for Research on Cancer, Lyon, France.

2 Deceased. Former staff member, Department of Gynecology and Obstetrics, Hebrew University—Hadassah Medical School, Jerusalem, Israel.

3 Department of Gynecology and Obstetrics, Hebrew University—Hadassah Medical School, Jerusalem, Israel.

4 Department of Occupational Health, Hebrew University—Hadassah Medical School, Jerusalem, Israel.

Thus cow's milk and beef were the main source of β-BHC residues in human milk from Japan.

These circumstances led to the banning of β-BHC in Japan in 1971. Studies carried out in 1972 showed a 40-50 percent decrease of BHC since the ban (*57*). The banning of some organochlorine insecticides in Sweden was followed by a decrease of these xenobiotics in milk. Average PCB levels in human milk in that country increased, however, due to the consumption of fish from the Baltic Sea where industrial waste had been discarded (*80*).

In noncotton regions of Guatemala, cow's milk averaged 0.025 ppm compared with 2.15 ppm in human milk; in this case, cow's milk and beef were not the main source of organochlorines in humans (*59*). Generally, cow's milk contained less than one tenth the quantity of total DDT (Σ DDT) found in human milk. Nearly 83 percent of 168 dairy samples investigated contained less than 20 ppb DDT (*14*). One cause for such differences, in addition to the degree of exposure, is that human mothers excrete in milk approximately 125 percent of the estimated DDT intake, but cows excrete only about 1.5 percent of their DDT intake. Human mothers apparently have a negative DDT balance while lactating (*38*).

Tables 1-6 summarize reports on residues of organochlorine compounds, i.e., some organochlorine insecticides and PCB's, in whole milk and in milk-extracted lipids in several countries.

The importance of studies providing assessment of milk contamination in a region at a given time is that figures obtained in one region can be compared with those from other regions or with subsequent studies in the area after improvement of environmental conditions.

TABLE 1. *Organochlorine residues in extracted lipids of human milk from ten nations*

Literature References	Nation	Residues, ppm						Sampling Year
		Σ DDT	BHC	Dieldrin	Heptachlor Epoxide	HCB	PCB's	
Westöö and Norén 1968 (*81*)	Sweden	2.2800-5.7100		0.0-0.2000				1968
Tuinstra 1971 (*77*)	Netherlands	2.5000	0.3000	0.1200	0.0600			1969
Engst and Knoll 1971 (*14*)	Germany	8.2000						1970
Acker and Schulte 1971 (*1*)	Germany	3.8000	0.5400			5.3000	3.5000	1971
Luquet et al. 1974 (*45*)	France	3.2400	1.7700	0.2300	0.2800	0.9800		1971-1973
Kontek et al. 1971 (*41*)	Poland	12.8700	0.3750					1971
Bogusz 1972 (*8*)	Poland	12.8700						1972
Denes and Tarjan 1969 (*11*)	Hungary	9.5000						1962-1963
Damaskin 1965 (*10*)	USSR	1.2200-4.8800						1965
Kroger 1972 (*42*)	USA	2.4000	0.0800		0.1600			1972
Quinby et al. 1965 (*62*)	USA	0.5000-10.5000						1965
Suzuki et al. 1973 (*71*)	Japan: Akita	3.5300	0.8700	0.3800				1970
Osaka Pref. 1973 (*60*)	Japan: Osaka	2.8110		0.0800				1971
Oura et al. 1972 (*61*)	Japan: Toyama						1.1000	1972
Miller and Fox 1973 (*50*)	Australia: urban	16.9000				1.2300		1973
	Australia: rural	8.6000				2.2000		1973

TABLE 2. *Organochlorine residues in human whole milk from ten European nations*

Literature References	Nation	Residues, ppb					Sampling Year
		Σ DDT	BHC	Dieldrin	HCB	PCB's	
Bjerk 1972 (*7*)	Norway	50.0-100.0				10.0	1972
Westöö and Norén 1968 (*81*)	Sweden	113.0					1968
Westöö et al. 1970 (*82*)	Sweden	120.0					1967-1969
Egan et al. 1965 (*13*)	England	130.0	13.0	6.0			1965
Heyndrickx and Maes 1969 (*27*)	Belgium	130.0					1969
Engst and Knoll 1971 (*14*)	Germany	230.0					1969
	Germany	130.0					1970
Engst and Knoll 1972 (*15*)	Germany	160.0					1970
Acker and Schulte 1971 (*1*)	Germany	112.0	18.0		153.0	3.0	1970
Knoll and Jayaraman 1973 (*36*)	Germany	320.0					1971
Knoll and Jayaraman 1973 (*37*)	Germany	300.0	70.0			0.0	1973
Kontek et al. 1971 (*41*)	Poland	280.0					1971
Bogusz 1972 (*8*)	Poland	670.0					1972
Gracheva 1969 (*20*)	USSR	0-1000.0					1964
Gracheva 1970 (*21*)	USSR	250.0					1966-1968
Komarova 1970 (*40*)	USSR	100.0					1970
	USSR	190.0					1970
Unterman and Sirghie 1969 (*78*)	Romania	560.0					1969
Mandroiu and Jordăchescu 1971 (*46*)	Romania		0-560.0				1971
Adamović et al. 1969 (*2*)	Yugoslavia	207.5	5.0				1969
Adamović et al. 1971 (*3*)	Yugoslavia		14.0	79.0			1971
Graca et al. 1974 (*19*)	Portugal: Lisbon	326.0					1972
	whole country	9.0-1044.0					1972

Organchlorine insecticides and PCB concentrations have been measured in human whole milk, milk-extracted lipids, or both. Knowing the levels of such compounds in whole milk facilitates calculation of the amount of organochlorine insecticides and PCB's ingested by the baby, and comparison of these figures with acceptable daily intakes established by legislation. Levels of organochlorine insecticides and PCB's in milk seem to vary with the lactation period (*22,37*). Most reports do not mention the period of milk sampling; others state results of sampling over a long period of lactation but do not give partial averages according to months of lactation.

The organochlorine insecticide and PCB content of human milk seems to be related to the degree of exposure. Japanese studies showed higher contamination in milk from the western prefectures of Japan where pesticides were used extensively (*25*). Seasonal variations sometimes occur. Higher residue levels are found in winter, probably because winter food contains large amounts of fat (*3*). Several studies reported higher values of organochlorine insecticides in nonfarming families; BHC and dieldrin were higher in the milk of urban mothers than of rural mothers (*24,31,39,73*). There was some correlation between organochlorine insecticide levels in milk and the daily intake of cow's milk and beef which were consumed in higher quantities by urban families (*24,66*). No significant differences between rural and urban DDT levels in mother's milk were found by Komarova (*40*). Organochlorine insecticide and PCB residues were higher in milk samples from underweight and normal-weight women than from overweight ones (*36,37*). The residues increased with age of the lactating women (*36*). Mothers who had nursed three or more babies had DDT concentration in the milk fat below the average (*42*).

This paper reports levels of organochlorine compounds in milk and plasma of Israeli mothers sampled during the first four days after delivery. Samples of blood and milk were taken on the same day.

TABLE 3. *Organochlorine residues in human whole milk, North and Central America*

Literature References	Nation	Residues, ppb					Sampling Year
		ΣDDT	BHC	Dieldrin	Heptachlor Epoxide	PCB's	
Musial et al. 1974 (*53*)	Canada: New Brunswick	35.0					1974
	Nova Scotia	19.0					
Laug et al. 1951 (*43*)	USA	130.0					1951
Quinby et al. 1965 (*62*)	USA: pool	170.0					1960-1961
	individual	120.0					
West 1964 (*79*)	USA	0-370.0					1962
Curley and Kimbrough 1969 (*9*)	USA	70.0	7.0	6.0			1967
Savage et al. 1973 (*63*)	USA	7.0-495.0	0-38.0	0-11.0	0-5.0	40.0-100.0	1971
Hagyard et al. 1973 (*22*)	USA	326.0					1973
Wilson et al. 1973 (*83*)	USA	170.0					1973
Lofröth 1971 (*44*)	Central America	3100.0					1971
Olszyna-Marzys et al. 1973 (*59*)	Guatemala: cotton region	4070.0	0-100.0				1973
	noncotton region	1830.0					

TABLE 4. *Organochlorine residues in human whole milk, Africa*

Literature References	Nation	Residues, ppb				Sampling Year
		ΣDDT	BHC	HCB	PCB's	
Gejvall et al. 1972 (*18*)	Ghana	29.0	30.0	86.0	5.0	1972

TABLE 5. *Organochlorine residues in human whole milk, Oceania*

Literature References	Nation	Residues, ppb				Sampling Year
		ΣDDT	BHC	Dieldrin	HCB	
Newton and Greene 1972 (*56*)	Australia	142.0			52.5	1970
Stacey and Thomas 1975 (*68*)	Australia	78.0	25.0	5.0		1970-1971
Siyali 1973 (*67*)	Australia	64.0		5.0	15.6	1973
Hornabrook et al. 1972 (*29*)	New Guinea	29.0-95.9				1972

TABLE 6. *Organochlorine residues in human whole milk, Japan*

Literature References	Prefecture	Residues, ppb					Sampling Year
		Σ DDT	BHC	Dieldrin	Hepta-chlor Epoxide	PCB's	
Tokutsu et al. 1970 (*74*)	Wakayama	71.0	105.0				1970
Narafu 1971 (*55*)	Aichi		20.0-400.0				1970-1971
Takeshita and Inuyama 1970 (*73*)	Shimane: farmers	79.0	142.9	0-12.9			1970
	nonfarmers	66.0	250.9	0-43.0			1970
Kato et al. 1971 (*34*)	Kanagawa	19.0-105.0	18.0-74.0	0-12.0			1971
Hayashi 1972 (*24*)	24 prefectures: farmers	56.3	92.6	3.7			1971
	nonfarmers	63.5	143.4				1971
Hayashi 1972 (*25*)	24 prefectures	60.7	125.9	3.7			1971
	36 prefectures	62.6	100.9	3.4	1.1		1971-1972
Hayashi 1974 (*26*)	38 prefectures	63.0	105.0	3.4	1.1		1971-1972
Nishimoto et al. 1972 (*57*)	Kochi & Nangoku					30.0	1971-1972
Yamagishi et al. 1972 (*85*)	Toyko: colostrum	30.0	25.0	7.0			1971
	milk	44.0	41.0	2.0			1971
Kojima et al. 1971 (*39*)	Akita I: farmers	52.0	63.0	<1.0			1971
	nonfarmers	50.0	55.2	<1.0			1971
	Akita II: farmers	39.0	14.0				1971
	nonfarmers	38.0	62.0				1971
Mori et al. 1971 (*52*)	Mie	5.0-12.0	19.0-86.0	1.0-5.0			1971
Matsuda et al. 1971 (*47*)	Ethime: farmers	4.0	71.0	2.0			1971
	nonfarmers	4.0	92.0	1.0			1971
Shimizu 1974 (*65*)	Saga		0.0-390.0				1971
			190.0				after ban
Shirakawa 1974 (*66*)	Wakayama	435.9	345.1	5.8			1971
BHC and DDT . . . 1972 (*6*)	36 prefectures	60.2	115.4			3.4	1971
		56.2	96.0		1.1	3.1	1972
Osaka prefecture 1973 (*60*)	Osaka	21.0	161.5	1.0			1971
		43.0	180.0	2.0			1972
Kawai et al. 1973 (*35*)	Ebetsu	78.0	32.0				1971-1972
	Ebetsu & other cities	108.0	40.0				1971-1972
	Muroran	133.0	54.0				1971-1972
	Sapporo	100.0	49.0				1971-1972
Oura et al. 1972 (*61*)	Toyama	33.0	49.0			30.0	1972
Hidaka et al. 1972 (*28*)	Kyoto	95.0	120.0	5.0		50.0	1972
Tottori Pref. 1972 (*76*)	Tottori	124.0	109.3	4.7	1.0		1972
Kamata 1972 (*33*)	Hiroshima	90.0-180.0	70.0-160.0				1972
	Shimane						
	Okayama						
Nagai 1972 (*54*)	Oshima	20.0	190.0				1972
	Nagato	31.0	219.0				1972
	Yanai	12.0	94.0	2.0-4.0			1972
	Assa	33.0	247.0				1972
Takano 1972 (*72*)	Iwate	58.7	78.0	3.6	0.4		1971-1973
Yamanashi Prefecture 1972 (*86*)	Yamanashi: rural	10.0-53.0	21.0-81.0	2.0-4.0	1.0-4.0		1972
	urban	7.0-77.0	17.0-75.0	1.0-5.0	0.0-1.0		1972
Matsushima 1972 (*48*)	Nagasaki		1288.0				1972
Hara et al. 1972 (*23*)	Gumma	6.0-39.0	7.0-22.0	2.0-12.0			1972
Study group 1972 (*70*)	Tokyo		33.0-440.0	4.0			1972
Inuyama and Takeshita 1973 (*31*)	Shimane	89.4	103.3	5.1			1973
Shimamoto et al. 1973 (*64*)	Matsuyama	65.0	109.0	2.0			1973
Yamada and Sakamoto 1973 (*84*)	Hiroshima	39.0	40.0				1973
Status quo . . . 1974 (*69*)	Saga	40.0	180.0				1974

Materials and Methods

Samples of blood and milk were obtained at random from 29 women 2-4 days after normal delivery. These women had had no known exposure to organochlorine insecticides or PCB's.

Plasma was separated from whole blood and kept at −20° C until analysis. The determination of organochlorine residues in plasma is common among researchers performing routine biological sampling (*12, 30, 49, 51, 74*). The plasma was kept at −20° C until analyzed. Milk was obtained directly in graduated tubes (about 2.5 cc) and kept at −20° C until analyzed. The whole quantity of collected milk was used in the chemical analysis in order to maintain the natural concentration of milk constituents. PCB's and organochlorine insecticides, including DDT and metabolites, dieldrin, γ-BHC, and heptachlor epoxide, were determined in both plasma and milk.

The amounts of organochlorine insecticides and PCB's were expressed in ppm in extracted lipids of plasma and milk, and in whole plasma and whole milk.

Lipids were extracted by a modification of the method of Folch et al. (*17*): 1.5 ml plasma was homogenized with 10 ml of a mixture of 1:1 chloroform/methanol (v/v). For milk, about 2.5 ml was homogenized with 17 ml of the same solvent; the exact quantity of milk was noted in each case. Homogenates were filtered through fat-free paper into centrifuge tubes. For plasma, 1.5 ml water was added; for milk, 7 ml was added. The whole solution was mixed with a stirring rod and afterward centrifuged 2-3 minutes until two separate phases were obtained. The upper phase was removed as completely as possible. The lower phase was transferred into a weight tube and evaporated by a nitrogen flow until constant weight was reached. The figure obtained was a reference point for the calculation of the amount of organochlorine insecticides

and PCB's in the extracted lipids. Organochlorine insecticides were separated from PCB's using the Armour and Burke method of chromatography on silicic-acid/celite column (*5*). Extracted lipids were dissolved in 20 ml petroleum ether and allowed to pass through the column. PCB's were obtained in the eluate. Organochlorine insecticides were eluted afterward with 20 ml of a mixture of 1 percent acetonitrile, 19 percent hexane, and 80 percent methylene chloride. Each of the two eluates was concentrated to a volume of 0.5 ml. Organochlorine insecticide and PCB levels were determined by gas chromatography with an electron-capture detector and a spiral glass column, 6 feet by 4 mm, containing a mixture of equal parts of 15 percent QF-1 and 10 percent DC-200 on chromosorb WHP, 80-100 mesh for PCB's and 5 percent QF-1 on chromosorb WHP, 80-100 mesh for organochlorines.

Compounds used as standards were Aroclor 1254 and a mixture of pure organochlorine insecticides: *p,p'*-DDT, *p,p'*-TDE (DDD), *p,p'*-DDE, *o,p'*-DDT, *o,p'*-TDE, *o,p'*-DDE, γ-BHC, dieldrin, and heptachlor epoxide.

The plasma sample from one donor had a very high level of PCB's; this sample was not included in the statistical processing of PCB residues.

Results and Comments

Lipids extracted from plasma had a narrower range of values than had those extracted from milk.

Milk had a higher proportion of lipids than had plasma: 15.0 g/liter compared to 5.3 g/liter. For individual cases there was no correlation between the amount of lipids extracted from plasma and the amount from milk. Among women with low lipids in plasma the quantity of lipids in milk varied widely.

Ranges, mean values, standard deviations, and percentages of lipids extracted from plasma and milk appear in Table 7.

TABLE 7. *Lipids extracted from human plasma and milk for organochlorine insecticide and PCB analyses, Israel*

Samples	No. cases	Extracted Lipids		
		Range	G/liter Mean± SD	%
Plasma	29	2.6- 8.4	5.28 ± 1.32	100
Milk	29	5.8-32.8	14.99 ± 7.78	284

The amount of fat in human milk is generally related to its proportions in the diet. The fat content of human milk has proved greater in women from nonfarming families than in those from farming families (*56*).

Tables 8-13 show mean levels of organochlorine insecticides (n:29) and PCB's (n:28) in whole plasma and milk, and in their extracted lipids.

The concentration of organochlorine insecticides was higher in extracted lipids of plasma than in those of milk: ΣDDT, 15.12 ppm versus 5.77 ppm; γ-BHC, 3.00 ppm versus 0.86 ppm; dieldrin, 2.01 ppm versus 0.58 ppm; heptachlor epoxide, 2.76 ppm versus 0.72 ppm ($p<0.01$) (Table 8). Concentrations of ΣDDT in whole plasma and milk were similar: 74 ppb versus 72 ppb. Gamma-BHC, dieldrin, and heptachlor epoxide had higher values in plasma: 15 ppb versus 10 ppb, 10 ppb versus 7 ppb, and 14 ppb versus 9 ppb, respectively ($p<0.01$) (Table 8).

The mean value of total PCB's was slightly higher in extracted lipids of plasma than in extracted lipids of milk; the difference was not statistically significant. Individual PCB compounds represented by peaks 11, 13, and 14 appeared in milk but there were no detectable amounts in plasma. The percentages of individual PCB compounds were similar for plasma and milk, with the exception of peak 6 which was higher in plasma ($p<0.01$), and peaks 2, 3, and 9 which were higher in milk (Table 9).

Whole plasma contained smaller quantities of total PCB's than did whole milk: 19.3 ppb versus 44.2 ppb ($p<0.01$). The statistical evaluation of individual PCB's showed

TABLE 8. *Organochlorines in human plasma and milk, Israel—1975*

Compound	Residues, ppm			
	Extracted Lipids		Whole Plasma and Milk	
	Plasma (Mean ± SD)	Milk (Mean ± SD)	Plasma (Mean ± SD)	Milk (Mean ± SD)
p,p'-DDT	2.6776 ± 1.5328	0.9724 ± 0.4893	0.0133 ± 0.0073	0.0122 ± 0.0056
p,p'-DDD	1.7788 ± 0.9220	0.8048 ± 0.4585	0.0087 ± 0.0037	0.0099 ± 0.0044
p,p'-DDE	3.9718 ± 1.8739	1.8139 ± 0.9026	0.0195 ± 0.0078	0.0217 ± 0.0073
o,p'-DDT	2.2319 ± 1.3544	0.6143 ± 0.3903	0.0107 ± 0.0058	0.0073 ± 0.0044
o,p'-TDE	1.5158 ± 1.3479	0.4818 ± 0.3613	0.0072 ± 0.0058	0.0060 ± 0.0048
o,p'-DDE	2.2327 ± 0.8842	0.7626 ± 0.4387	0.0112 ± 0.0040	0.0095 ± 0.0036
γ-BHC	3.0044 ± 1.3858	0.8607 ± 0.3713	0.0147 ± 0.0057	0.0101 ± 0.0035
Dieldrin	2.0104 ± 1.0886	0.5806 ± 0.3132	0.0099 ± 0.0051	0.0070 ± 0.0077
Heptachlor Epoxide	2.7601 ± 1.3366	0.7177 ± 0.4824	0.0136 ± 0.0057	0.0091 ± 0.0045
Total *p,p'*-DDT	8.8809 ± 4.1174	3.7881 ± 1.8980	0.0437 ± 0.0178	0.0467 ± 0.0165
Total *o,p'*-DDT	6.2349 ± 3.1287	1.9776 ± 1.0950	0.0304 ± 0.0127	0.0249 ± 0.0110
ΣDDT	15.1158 ± 7.2114	5.7738 ± 2.8220	0.0740 ± 0.0294	0.0717 ± 0.0250

TABLE 9. *PCB's in human plasma and milk, Israel—1975*

Peaks	Residues, ppm			
	Extracted Lipids		Whole Product	
	Plasma (Mean ± SD)	Milk (Mean ± SD)	Plasma (Mean ± SD)	Milk (Mean ± SD)
1	0.0609 ± 0.2149	0.0316 ± 0.0959	0.0003 ± 0.0010	0.0003 ± 0.0010
2	0.0809 ± 0.3167	0.1337 ± 0.6949	0.0004 ± 0.0016	0.0010 ± 0.0053
3	0.0499 ± 0.1414	0.0707 ± 0.3174	0.0002 ± 0.0006	0.0005 ± 0.0024
4	0.0822 ± 0.2412	0.0818 ± 0.2177	0.0005 ± 0.0045	0.0013 ± 0.0026
5	0.2469 ± 0.3691	0.1868 ± 0.3485	0.0013 ± 0.0020	0.0031 ± 0.0048
6	2.1224 ± 1.1710	0.9904 ± 1.1188	0.0103 ± 0.0050	0.0124 ± 0.0120
7	— —	0.0254 ± 0.1319	— —	0.0005 ± 0.0026
8	0.3146 ± 0.5616	0.3084 ± 0.5256	0.0016 ± 0.0028	0.0050 ± 0.0077
9	0.2627 ± 0.3130	0.4341 ± 0.7074	0.0013 ± 0.0014	0.0065 ± 0.0089
10	0.7321 ± 0.6899	0.4694 ± 0.5705	0.0033 ± 0.0026	0.0069 ± 0.0075
11	— —	0.0631 ± 0.1303	— —	0.0014 ± 0.0032
12	— —	— —	— —	— —
13	— —	0.1931 ± 0.1900	— —	0.0032 ± 0.0040
14	— —	0.1011 ± 0.1503	— —	0.0019 ± 0.0035
Total	3.9884 ± 2.4448	3.1008 ± 3.0502	0.0193 ± 0.0126[1]	0.0442 ± 0.0412[1]

[1] $p < 0.01$.

TABLE 10. *Organochlorine levels in human whole plasma and milk by age, Israel—1975*

Sample	Age, yr	Residues, ppb				
		Σ DDT	γ-BHC	Dieldrin	Heptachlor Epoxide	PCB's
Plasma	20-29	63.6[1]	13.4	8.3[2]	12.2	21.1
	30-39	89.2[1]	16.3	12.4[2]	15.8	16.0
Milk	20-29	73.5	10.2	7.0	9.8	56.4[1]
	30-39	64.0	9.4	6.6	7.2	18.2[1]

[1] $p < 0.05$
[2] $p < 0.01$.

TABLE 11. *Ratio of organochlorine residues in human whole milk : plasma by age, Israel—1975*

Age, yr	Σ DDT	γ-BHC	Dieldrin	Heptachlor Epoxide	PCB's
20-29	115.57	76.12	84.34	80.33	267.29
30-39	71.75	57.67	53.23	45.57	113.75

TABLE 12. *Organochlorine levels in human whole plasma and milk by weight, Israel, 1975*

Sample	Weight, kg	Residues, ppb				
		Σ DDT	γ-BHC	Dieldrin	Heptachlor Epoxide	PCB's
Plasma	Over 72	72.9	15.5	8.5	14.1	18.1
	Under 63	62.8	11.6	7.9	10.3	15.9
Milk	Over 72	67.8[1]	9.2[1]	6.0[2]	7.6	24.1
	Under 63	92.5[1]	12.6[1]	8.7[2]	12.0	66.1

[1] $p < 0.05$.
[2] $p < 0.01$.

TABLE 13. *Ratio of organochlorine residues in human whole milk : plasma by weight, Israel—1975*

Weight, kg	Σ DDT	γ-BHC	Dieldrin	Heptachlor Epoxide	PCB's
Over 72	93.0	59.3	70.6	53.9	133.14
Under 63	147.3	108.2	110.1	116.5	415.72

differences for the compound represented by peak 10 ($p<0.05$) (Table 9). A larger proportion of organochlorine insecticides in milk than in plasma was also reported (*75*).

Average organochlorine levels reported here are rather low compared with those reported in studies from 10 other nations (Table 1).

Mean levels of organochlorines in whole plasma were lower in the younger age group of women sampled: Σ DDT, 63.6 ppb versus 89.2 ppb ($p<0.05$); γ-BHC, 13.4 ppb versus 16.3 ppb; dieldrin, 8.3 ppb versus 12.4 ppb ($p<0.01$); and heptachlor epoxide, 12.2 ppb versus 15.8 ppb (Table 10). All organochlorines were excreted in milk in a higher proportion among the younger women (Table 10). The ratios of organochlorine insecticides and PCB's in whole milk to those in plasma of the two age groups are presented in Table 11. Higher concentrations of organochlorine insecticides and PCB's are excreted in milk by the younger women, indicating that their offspring are exposed to greater danger than are those of the older mothers.

This finding contradicts that of Knoll and Jayarman (*36*) who maintain that organochlorines in milk increase with age of the donor.

Persons weighing over 72 kg had higher mean organochlorine insecticide and PCB levels in plasma than had those

under 63 kg. These differences are not statistically significant (Table 12).

Organochlorine insecticide and PCB concentrations in the milk of persons heavier than 72 kg were lower than in the group which weighed less than 63 kg: Σ DDT, 67.8 versus 92.5 ppb; ($p<0.05$); γ-BHC, 9.2 versus 12.6 ppb ($p<0.05$); dieldrin, 6.0 versus 8.7 ppb ($p<0.01$); heptachlor epoxide, 7.6 versus 12.0 ppb; and PCB's, 24.1 versus 66.1 ppb (Table 12). The ratios of organochlorine insecticides and PCB's in whole milk to those in plasma among the two weight groups are presented in Table 13. It is obvious that smaller concentrations of organochlorine insecticides and PCB's are excreted by women weighing over 72 kg than by those under 63 kg.

Such data call for suggestions of measures to prevent the occurrence of high levels of organochlorine insecticides and PCB's in human milk. Banning some organochlorine compounds in countries where residues in milk were high has proved effective.

Special care for the nutrition and environment of the mother during pregnancy and lactation may be beneficial. Mothers could avoid fat food, which contains larger quantities of organochlorine insecticides and PCB's and sea fish, which contain large quantities of PCB's. Heavily polluted work environments should be avoided. Abstention from the use of insecticides or other noxious compounds in households is advisable.

Although breast feeding is generally considered desirable, infants of mothers heavily exposed to chemical hazards should not be breast-fed.

Periodic surveys of organochlorine levels in mother's milk may provide a base for establishing preventive measures in the future.

LITERATURE CITED

(1) Acker, L., and E. Schulte. 1971. On the occurrence of BHC and PCB along with organochlorine insecticides in human adipose tissue and in human milk. Ernaehrungsforschung 16(4):559-567.

(2) *Adamovic, V. M., M. Hus, and V. Djukic.* 1969. Cumulation of organochlorine insecticides in the organism of the inhabitants of Serbia. Second Yugoslav Symp. on Pesticides, Zagreb.

(3) *Adamovic, V., B. Sokic, and O. Petrovic.* 1971. On factors influencing the occurrence of organochlorine insecticides in newborns. Ernaehrungsforschung 16(4):579-585.

(4) *Allen J. R.* 1975. Response of Primates to PCB Exposures. Fed. Proc. 34(8):1675-1679.

(5) *Armour, J. A., and J. A. Burke.* 1970. Method for separating polychlorinated biphenyls from DDT and its analogs. J. Assoc. Off. Anal. Chem. 53(4):761-768.

(6) *1972.* BHC and DDT residues in human milk on the decline in Japan. Pestic. Business 56:458.

(7) *Bjerk, J. E.* 1972. DDT and polychlorinated biphenyl residues in human material in Norway. Tidsskr. Nor. Laegefor. 92(1):15-19.

(8) *Bogusz, M.* 1972. Organochlorine insecticides: the need for a realistic evaluation of risk. Pol. Tyg. Lek. 27(17):637-640.

(9) *Curley, A., and R. Kimbrough.* 1969. Chlorinated hydrocarbon insecticides in plasma and milk of pregnant and lactating women. Arch. Environ. Health 18(2):156-164.

(10) *Damaskin, V. I.* 1965. O stepeni kumuliatsii DDT v organizme cheloveka pri postuplenii s pishchevymi produktami i ego toksicheskom vozdeistvii [the extent of accumulation of DDT in the human body due to its presence in food and its toxic effect]. Gig Sanit. 30:109.

(11) *Denes, A., and R. Tarjan.* 1969. The effect of accumulation of DDT in the human body due to its presence in food and its toxic effects. Egeszsegtudomany 13(3):212-217.

(12) *Edmundson, W. F., J. E. Davies, and M. Cranmer.* 1970. DDT and DDE in blood and DDA in urine of men exposed to 3 percent DDT aerosol. U.S. Public Health Rep. 85(5):457-463.

(13) *Egan, H., R. Goulding, J. Roburn, and J. O'G. Tatton.* 1965. Organochlorine pesticide residues in human fat and human milk. Br. Med. J. 11(2):66-69.

(14) *Engst, R., and R. Knoll.* 1971. DDT and DDE residues in human milk. Ernaehrungsforschung 16(4):569-575.

(15) *Engst, R., and R. Knoll.* 1972. Organochlorine residues in human milk. Pharmazie 27(8):526-531.

(16) *Farvar, M. T.* 1972. Ecological implications of insect control in Central America: Agriculture, public health and development. Diss. Abstr. Int. 33(5):1939 B.

(17) *Folchi-Pi, J., M. Lees, and G. H. Sloane Stanley.* 1957. A simple method for isolation and purification of the total lipids from animal tissues. J. Biol. Chem. 226(1):497-509.

(18) *Gejvall, T., S. Jensen, and G. Lofroth.* 1972. Organochlorine Compounds in Some Ghanaian Human Milk samples. University of Stockholm, Sweden (preliminary draft).

(19) *Graca, J., S. Fernandes, and H. C. Mourao.* 1974. Organochlorine insecticide residues in human milk in Portugal. Pestic. Monit. J. 8(3):148-156.

(20) *Gracheva, G. V.* 1969. The possibility of DDT accumulation in the organism of persons not having occupational contact with it. Faktory Vneshn. Sredy Ikh. Znach. Zdorov'ya Naseleniya 1(1):125-129.

(21) *Gracheva, G. V.* 1970. Vydelenie DDT s grudnym molokom kormiashchikh zhenshchin, ne imevskikn professional'noge konakata s nim [DDT secretion in the breast milk of nursing women not having occupational contact with it]. Vopr. Pitan. 29(6):75-78.

(22) *Hagyard, S. B., W. H. Brown, J. W. Stull, F. M. Whiting, and S. R. Kemberling.* 1973. DDT and DDE content of human milk in Arizona. Bull. Environ. Contam. Toxicol. 9(3):169-172.

(23) *Hara, Y., H. Masago, K. Karino, T. Takijima, I. Fukushima, S. Fujii, T. Tano, T. Kobayashi, O. Kurihara, K. Sudo, and T. Muto. 1972.* On pesticide residues in foods, first report. Organochlorine pesticide residues. Ann. Rep. Gumma Prefect. Inst. Public Health Cent. Study Environ. Pollut. 4:83-86.

(24) *Hayashi, M. 1972.* Pesticide pollution of mother's milk. J. Jpn. Med. Assoc. 68(12):1281-1282.

(25) *Hayashi, M. 1972.* Pollution of mother's milk by organochlorine insecticides. Jpn. J. Public Health 19(9):437-441.

(26) *Hayashi, M. 1974.* Mother's milk and environmental pollution. J. Pediatr. Pract. 37(9):1113-1119.

(27) *Heyndrickx, A., and R. Maes. 1969.* The excretion of chlorinated hydrocarbon insecticides in human mother's milk. J. Pharm. Belg. 24(9-10):459-463.

(28) *Hidaka, K., T. Ohe, and K. Fujiwara. 1972.* PCB and organochlorine pesticides in mother's milk. Prog. Med. 82(8):519-520.

(29) *Hornabrook, R.W., P. G. Dyment, E. P. Gomes, and J. S. Wiseman. 1972.* DDT residues in human milk from New Guinea natives. Med. J. Aust. 25(1):1297-1300.

(30) *Inoue, Y., S. Abe, H. Esaki, and M. Takamatsu. 1973.* Polychlorinated biphenyls in human blood. Kurume Med. J. 29(2):83-86.

(31) *Inuyama, Y., and T. Takeshita. 1973.* Survey of pesticide residues and PCB's in mother's milk and human adipose tissue. Ann. Rep. Shimane Prefect. Inst. Pub. Health Environ. Pollut. 15:37-39.

(32) *Juszkiewicz, T., T. Szprengier, and T. Radomanski. 1975.* Mercury content of human milk. Pol. Tyg. Lek. 30(9):365-366.

(33) *Kamata, T. 1972.* Hygienic studies on pesticide residues, part 3. Determination of organochlorine pesticide residues in human tissues and other samples. Jpn. J. Hyg. 27(5):439-443.

(34) *Kato, K., T. Yamada, S. Watanabe, Y. Wado, et al. 1971.* Analyses of residual pesticides in vegetables, cow's milk and mother's milk. Annu. Rep. Kanagawa Prefect. Inst. Public Health 21:85-92.

(35) *Kawai, Y., Y. Hori, Y. Nigawa, I. Yamamoto, M. Kitayama, and K. Mori. 1973.* On the pollution of mother's milk by pesticides and PCB's in Hokkaido. J. Food Hyg. Soc. Jpn. 14(3):302-303.

(36) *Knoll, W., and S. Jayaraman. 1973.* Organochlorine pesticide residues in human milk. Z. Gesamte Hyg. 19(1):43-45.

(37) *Knoll, W., and S. Jayaraman. 1973.* On the contamination of human milk with chlorinated hydrocarbons. Nahrung 17(5):599-615.

(38) *Knowles, J. A. 1974.* Breast milk: a source of more than nutrition for the neonate. Clin. Toxicol. 7(1):69-82.

(39) *Kojima, S., M. Saito, H. Konno, and K. Ozowa. 1971.* Results of investigation of organochlorine pesticide residues in mother's milk and in blood of the mothers. Rep. Akita Prefect. Inst. Public Health 16:65-68.

(40) *Komarova, L. I. 1970.* DDT excretion with the breast milk and its effect on the body of the mother and child. Pediatr. Akush. Hinekol 35(1):19-20.

(41) *Kontek, M., S. Kubacki, S. Paradowski, and B. Wierzchowiecka. 1971.* Determination of organic chlorine pesticides in human milk. Pediatr. Pol. 46(2):183-188.

(42) *Kroger, M. 1972.* Insecticide residues in human milk. J. Pediatr. 80(3):401-405.

(43) *Laug, E. P., F. M. Kunze, and C. S. Prickett. 1951.* Occurrence of DDT in human fat and milk. Arch. Ind. Hyg. 3(3):245-246.

(44) *Lofroth, G. 1971.* Who cares about DDT? Ecologist 1(17):8-9.

(45) *Luquet, F. M., J. Gours, J. Casalis. 1974.* Contamination of human milk by organochlorine pesticide residues in France. Aliment. Vie 62(1):40-69.

(46) *Mandroiu, V., and M. Jordachescu. 1971.* Determination of the BHC content in the human organism. Igiena 20(6):363-364.

(47) *Matsuda, H., T. Shimamoto, T. Ito, and K. Ogida. 1971.* On the analytical results of organochlorine pesticide residues in mother's milk. Rep. Ehime Prefect. Hyg. Lab. 33:43-48.

(48) *Matsushima, S. 1972.* Pollution of food by agricultural chemicals and the diet. J. Clin. Nutr. 40(5):555-563.

(49) *Mick, D. L., K. R. Long, and P. Bonderman. 1971.* Aldrin and dieldrin in the blood of pesticide formulators. Am Ind. Hyg. Assoc. Sept. 72, pp 94-99.

(50) *Miller, G. J., and J. A. Fox. 1973.* Chlorinated hydrocarbon pesticide residues in Queensland human milk. Med. J. Aust. 2(6):261-264.

(51) *Morgan, D. P., C. C. Roan, and E. H. Pischal. 1972.* Transport of DDT, DDE, and dieldrin in human blood. Bull. Environ. Contam. Toxicol. 8(6):321-326.

(52) *Mori, Y., K. Ito, K. Sakurai, M. Mori, amd T. Sudo. 1971.* On the results of investigation of milk pollution by pesticide residues. Ann. Rep. Mie Prefect, Inst. Public Health 18:59-68.

(53) *Musial, C. J., O. Hutzinger, V. Zitko, and J. Crocker. 1974.* Presence of PCB, DDE and DDT in human milk in the provinces of New Brunswick and Nova Scotia, Canada. Bull. Environ. Contam. Toxicol. 12(3):258-267.

(54) *Nagai, I. 1972.* Residues of organochlorine pesticides in mother's milk in Yamaguchi Prefecture. Ann. Rep. Yamaguchi Prefect. Res. Inst. Public Health 14:93-94.

(55) *Narafu, T. 1971.* Pollution of cow's milk and human milk by BHC. J. Clin. Nutr. 39(1):26-34.

(56) *Newton, K. G., and N. C. Greene. 1972.* Organochlorine pesticide residue levels in human milk—Victoria, Australia—1970. Pestic. Monit. J. 6(1):4-8.

(57) *Nishimoto, T., M. Uyeta, S. Taue, and K. Okikazawa. 1972.* Organochlorine pesticide residues and PCB's in breast milk. Progr. Med. 82(9):974-975.

(58) *Nishimura, H. 1973*. Teratogenic substances. Int. Chem. Eng. 13(4):774-780.

(59) *Olszyna-Marzys, A. E., M. De Campos, M. Taghi Farvar, and M. Thomas. 1973*. Chlorinated pesticide residues in human milk in Guatemala. Bol. Sanit. Panamer. 74:93-107.

(60) *Osaka Prefect. 1973*. The countermeasures for damages due to agricultural pesticides. 2nd item of lst clause of Chapter XII. A draft of the plan of Environmental Administration. pp. 392-395.

(61) *Oura, H., H. Kobayashi, T. Oura, I. Senda, and K. Kubota. 1972*. On the pollution of human milk by PCB's and organochlorine pesticides. J. Jpn. Assoc. Rural Med. 21(2):300-301.

(62) *Quinby, G. E., J. F. Armstrong, and W. F. Durham. 1965*. DDT in human milk. Nature 207(4998):726-728.

(63) *Savage, E. P., J. D. Tessari, J. W. Malberg, H. W. Wheeler, and J. R. Bagby. 1973*. Organochlorine pesticide residues and polychlorinated biphenyls in human milk, Colorado—1971-72. Pestic. Monit. J. 7(1):1-5.

(64) *Shimamoto, T., H. Matsueda, M. Yoshinouchi, E. Okinaga, K. Mori, S. Yamatake, S. Nakajima, and K. Aihara. 1973*. Results of a survey on PCB and organochlorine pesticide residues in mother's milk. Ann. Rep. Ehime Prefect. Inst. Hyg. Sci. 35:71-73.

(65) *Shimizu, S. 1974*. Results of pursuing investigation on pesticide residues in Saga Prefecture. Jpn. J. Public Health 21(4):239-245.

(66) *Shirakawa, M. 1974*. On the results of investigation on the pesticide residues in the milk from lactating women of coastal areas in Wakayama Prefecture. Jpn. J. Hyg. 29(1):94.

(67) *Siyali, D. S. 1973*. Polychlorinated biphenyls, hexachlorobenzene and other organochlorine pesticides in human milk. Med. J. Aust. 2(17):815-818.

(68) *Stacey, C. I., and B. W. Thomas. 1975*. Organochlorine pesticide residues in human milk, Western Australia—1970-71. Pestic. Monit. J. 9(2):64-66.

(69) *1974*. The status quo of pollution by pesticides and its countermeasures. Status quo of environmental pollution and its countermeasures in Saga Prefecture. Saga Prefectural Office, pp 464-480.

(70) *Study Group: National Inst. of Hygienic Sci., Setayaga, Tokyo, Japan. 1972*. Studies on the analysis of pesticide residues in food (VII). Organochlorine pesticide residues in mother's milk. J. Food Hyg. Soc. Jpn. 13:422-437.

(71) *Suzuki, Y., H. Sugaya, and S. Sasaki. 1973*. Results of three years' tracing investigation of organochlorine pesticide residues in humans. J. Jpn. Assoc. Rural Med. 22(3):276-277.

(72) *Takano, H. 1972*. Results of inspection of pesticide residues in mother's milk and market milk. Annu. Rep. Iwate Inst. Public Health 15:81-91.

(73) *Takeshita, T., and Y. Inuyama. 1970*. Organochlorine residues in mother's milk and blood. Annu. Rep. Shimane Prefect. Inst. Public Health 12:27-28.

(74) *Tokutsu, K., T. Koyama, and T. Yokoyama. 1970*. Pesticide residue in mother's milk and plasma in Wakayama Prefecture. Annu. Rep. Wakayama Prefect. Inst. Public Health 19:59-62.

(75) *Tottori Prefectural Hygiene Research Institute, Tottori, Japan. 1971*. Tests and investigations on pesticide residues in mother's milk and blood. Rep. Tottori Prefect. Hyg. Res. Inst. 11:19.

(76) *Tottori Prefectural Hygiene Research Institute, Tottori, Japan. 1972*. Tests and investigations of pesticide residues in mother's milk. Rep. Tottori Prefect. Hyg. Res. Inst. 12:22.

(77) *Tuinstra, L. G. M. 1971*. Organochlorine insecticide residues in human milk in the Leiden region. Ned. Melk. Zuiveltijdschr. 25(1):24-32.

(78) *Unterman, W. M., and E. Sirghie. 1969*. Igiena Buc. 18(4):221. Ref. in Dairy Sci. Abstr. 32(3):192 (1970).

(79) *West, Irma. 1964*. Pesticides as contaminants. Arch. Environ. Health 9(5):626-633.

(80) *Westoo, G. 1974*. Changes in the levels of environmental pollutants (Hg, DDT, dieldrin, PCB) in some Swedish foods. Ambio 3(2):79-83.

(81) *Westoo, G., and K. Noren. 1968*. Nordforsk Biocid—Information 14(10):6-7.

(82) *Westoo, G., K. Noren, and M. Andersson. 1970*. The levels of organochlorine pesticides and polychlorinated biphenyls in margarine, vegetable oils and some foods of animal origin on the Swedish market in 1967-69. Var Foda 22(2-3):9-31.

(83) *Wilson, D. J., D. J. Locker, C. A. Kitzen, J. T. Watson, and W. Schaffner. 1973*. DDT concentrations in human milk. Am. J. Dis. Child. 125(6):814-817.

(84) *Yamada, T., and Y. Sakamoto. 1973*. Results of survey of pesticide residues in mother's milk and soil. Hiroshima Prefect. Inst. Prevent. Environ. Pollut. Annu. Rep. 3:57-58.

(85) *Yamagishi, T., K. Takeba, C. Fujimoto, K. Morimoto, and M. Haruta. 1972*. On the organochlorine pesticide residues in mother's body and her foetus' body. Rep. Tokyo Pub. 50:44-45.

(86) *Yamanashi Prefect. Inst. for Public Health, Yamanashi, Japan. 1972*. Results of investigation of mother's milk pollution by organochlorine pesticides. Annu. Rep. Yamanashi Prefect. Inst. Public Health 15:20.

Insecticide Residues in Human Milk from Arkansas and Mississippi, 1973-74 [1]

Sandra C. Strassman and Frederick W. Kutz

ABSTRACT

Between September 1973 and February 1974, 57 samples of human milk were collected from women residing in selected areas of Arkansas and Mississippi. Residues of p,p'-DDT, p,p'-DDE, p,p'-TDE, β-BHC, dieldrin, heptachlor epoxide, oxychlordane, and trans-nonachlor were measured by electron-capture gas chromatography; trace amounts of o,p'-DDT and polychlorinated biphenyls were also detected. Additional analytical procedures were employed to confirm the presence of specific residues.

Introduction

Residues of certain organochlorine insecticides and their transformation products have been found by many investigators in various human components such as adipose tissue, whole blood and blood serum, urine, feces, and milk. Demonstration of pesticide residues and their metabolites in human milk presents a critical health issue from at least two standpoints. First, the residues indicate total body burden of pesticides in the donor mother, providing some measure of lipophilic insecticides stored and accumulating in her body. Second, if the mother breastfeeds the newborn, her milk becomes a major vehicle for exposing the baby to insecticide residues.

Exposure to these chemicals begins in utero by transplacental passage (*1, 7*). After birth, exposure may continue through ingestion, respiration, and absorption through the skin and mucous membranes. Since babies are usually kept in protected environs, ingested food probably presents the major source of exposure to these pollutants.

This paper reports levels of organochlorine pesticide residues and the industrial pollutant, polychlorinated biphenyls (PCB's), detected in milk collected from women residing in selected counties of Arkansas and Mississippi. All information presented was developed by the National Human Monitoring Program for Pesticides of the U.S. Environmental Protection Agency. This program evaluates the exposure to pesticides experienced by the general population of the conterminous United States, and attempts to identify changes and trends when they occur. Details of the program have been reported by Yobs (*11*) and Kutz et al.(*5*).

Collection and Sampling

Between September 1973 and February 1974, milk was collected from donors residing in specified counties of Arkansas and Mississippi. All milk was analyzed in May 1975 for selected organochlorine insecticides, their transformation products, and PCB's.

Since the original intent of this study was to collect human milk for detection of chlorodioxins, possible contaminants of the herbicide 2,4,5-T (a 2,4,5-trichlorophenoxyacetic acid derivative), the survey design was limited to the collection of milk from women who probably had been exposed to this pesticide. Consequently, counties selected for the project (Figure 1) were those in which rice was grown or which exchanged public services with rice-growing areas of Arkansas and Mississippi where 2,4,5-T was being used or had been used recently.

Milk was collected from lactating mothers during their hospitalization after routine delivery or during postpartum examinations, and from members of cooperating LaLeche League chapters. Information received with each milk sample included the donor's age, race, county and State of residence, date of parturition, and any known pathological conditions. Since the object of the study was to reflect the pesticide burden in milk from the general population of the areas, samples were collected only from healthy women with no known occupational exposure to

[1] Ecological Monitoring Branch, Technical Services Division (WH-569), U.S. Environmental Protection Agency, Washington, D.C. 20460.

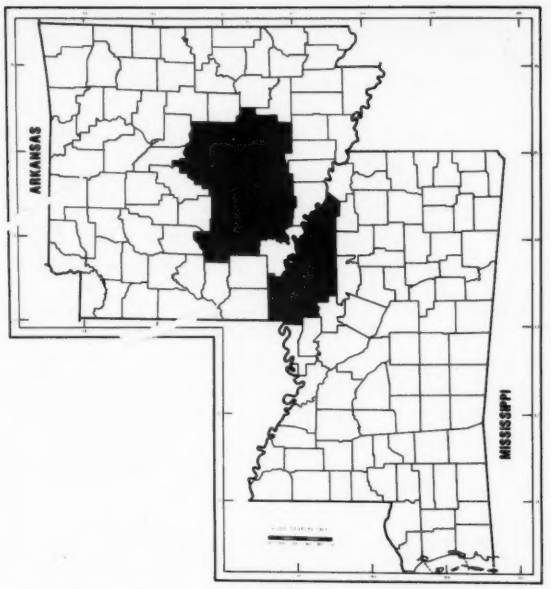

FIGURE 1. *Counties in Arkansas and Mississippi selected for sampling human milk for pesticide residue analysis, 1973-74*

pesticides. All individuals had established area residency; samples were not taken from transient or new residents.

Part of each milk sample was analyzed for organochlorine residues. The remainder is being retained for future chlorodioxin analysis.

Approximately one-half ounce of milk was manually expressed by each participant directly into a clean, pesticide-free glass bottle. Hind milk, which occurs after several minutes of nursing, was requested because of its high percentage of fat. Samples were immediately frozen and stored until analysis.

Chemical Analysis

All analyses were performed by a laboratory under contract to EPA following methods specified by the National Human Monitoring Program for Pesticides. The laboratory was required to maintain external quality-assurance standards.

Residues were extracted by a modification of the procedures described by Curley and Kimbrough (*2*) and Giuffrida et al. (*3*): the lipid was isolated from the milk, pesticides were extracted from the lipid, and the extract was cleaned up. Using the modified Mills-Olney-Gaither procedure (*10*), analysis was limited to determination of the chlorinated hydrocarbons presented in Table 1.

TABLE 1. *Chemicals detectable in human milk*[1]

CHEMICAL	LIMITS OF DETECTABILITY, PPB
o,p'-DDT	20
p,p'-DDT	20
o,p'-DDE	20
p,p'-DDE	10
o,p'-TDE	20
p,p'-TDE	20
α-BHC	10
β-BHC	20
γ-BHC (lindane)	10
δ-BHC	10
Endrin	20
Aldrin	10
Dieldrin	10
Heptachlor	10
Heptachlor epoxide	10
Oxychlordane	20
trans-Nonachlor	20
Hexachlorobenzene	10
Mirex	100
Polychlorinated biphenyls	1000

[1] Using the modified Mills-Olney-Gaither procedure (*10*).

After each sample was thawed and homogenized by a supersonic disintegrator, whole milk was weighed into a clean glass centrifuge bottle. Pre-cleaned glass wool was added to the centrifuge bottle to adhere to all the coarse precipitate of milk solids formed during the subsequent acetone extraction. Contents of the centrifuge bottle were extracted with acetone three times and pooled in a separatory funnel. Solids were separated from the acetone after each extraction by centrifugation. The remaining coarse milk solids were extracted twice with *n*-hexane, and these extracts were combined with acetone extracts in the separatory funnel. The combined *n*-hexane and acetone extracts were washed three times with 2 percent sodium sulfate, dried through an anhydrous sodium sulfate column, and concentrated in a Kuderna-Danish evaporator to approximately 5 ml. The concentrated extract was cleaned up by liquid-liquid acetonitrite partitioning and florisil procedures as described by Thomspon (*10*).

Residues were identified and quantified on a Micro-Tek 220 gas chromatograph equipped with tritium electron-capture detectors using two columns with different resolution characteristics. Column dimensions were 1.5 percent OV-17/1.95 percent QF-1 and 4 percent SE-30/6 percent OV-210. A Coulson electrolytic conductivity detector operated in the chloride mode was used to confirm *p,p'*-DDT and *p,p'*-DDE in every fifth sample (*9*). Results were reported on a whole-milk basis and the percent extractable lipid material was noted for each sample.

The 6 percent florisil fraction of each sample was composited for confirmation of selected pesticide residues by combined gas chromatography / mass spectrometry (GC-MS) and thin-layer chromatography.

Residue data, presented on a whole milk basis, were characterized by calculating the following statistical parameters:

Sample Size—total number of samples analyzed.

Percent Positive—percentage of the total number of samples in which a quantifiable residue of a given pesticide was detected.

Percent Trace—percentage of the total number of samples in which a residue of a given pesticide was reported but could not be quantified.

Extreme Values—highest and lowest values detected.

Arithmetic Mean—calculated using the standard formula.

Mean of Positives—arithmetic mean of residues found at quantifiable levels; reports of zero and trace amounts were excluded.

Residues present in trace amounts were identified on two columns; they could not, however, be quantified. In calculating the arithmetic means, only reports of quantifiable amounts of pesticide residues were considered; reports of trace amounts were treated as zero. Where a trace level represented the minimum value, this was indicated.

Results and Discussion

A demographic summary of the donors of the 57 human milk samples is presented in Table 2. The mean percent extractable lipid is included for each category.

The mean age of the 57 mothers was 27 years. Seventeen donors (29.8 percent) were Negroes; 40 (70.2 percent) were Caucasians. Sampling occurred from 1 to 448 days after delivery; the median postpartum time was 41 days. Lipid material extracted from each milk sample ranged from 0.6 to 8.8 percent, with a mean value of 3.0 percent.

Detected residues of the pesticides and their metabolites presented in Table 3 reflect donors' previous exposure to the chemicals; residues of PCB's represent exposure to these industrial chemicals. PCB's were present in trace amounts, below 1 ppm, in every sample. The presence of the compounds was confirmed in a composite of all extracts by combined GC-MS; hexachlorobiphenyls were the major components.

All milk samples showed evidence of prior exposure to DDT. The Σ DDT equivalent (*o,p'*-DDT + *p,p'*-DDT + 1.114 [*o,p'*-DDE + *p,p'*-DDE + *o,p'*-TDE + *p,p'*-TDE]) is calculated by adjusting the DDE and TDE transformation products of DDT by a molecular-weight-based constant to convert them to an equivalent weight of DDT. Thus the Σ DDT equivalent is a conglomerate figure ex-

TABLE 2. *Demographic summary of donors sampled for insecticide residues in human milk, Arkansas and Mississippi—1973-74*

Geographic Location	No. Samples	Percent Caucasians	Percent Negroes	Mean Age, Yr.	Median No. Postpartum Days	Mean Extractable Lipid Material, %
Mississippi	8	12.5	87.5	29.5	4	2.7
Arkansas	49	79.6	20.4	26.6	110	3.0
Combined Survey	57	70.2	29.8	27.0	41	3.0

TABLE 3. *Organochlorine pesticide residues in 57 human whole milk samples, Arkansas and Mississippi—1973-74*

Pesticide	Samples with Residues, %		Residues, ppm			
	Positive	Trace	Arithmetic Mean	Mean of Positives	Extreme Values	
					Minimum	Maximum
Σ DDT equivalent[1]	100.0	0	0.344	0.344	0.02	2.76
p,p'-DDT[2,3]	100.0	0	0.092	0.092	0.01	0.84
p,p'-DDE[2,3]	100.0	0	0.227	0.227	0.01	1.72
β-BHC[4]	36.8	63.2	0.005	0.014	trace	0.01
Dieldrin[4]	28.1	73.9	0.004	0.012	trace	0.05
Heptachlor epoxide[4]	35.1	64.9	0.004	0.012	trace	0.03
Oxychlordane[4]	45.6	54.4	0.005	0.012	trace	0.02
trans-Nonachlor[4]	14.1	86.0	0.001	0.010	trace	0.01
PCB's[2,5]	100.0	100.0	trace	trace	trace	trace

[1] Σ DDT equivalent = *o,p'*-DDT + *p,p'*-DDT + 1.114 (*o,p'*-DDE + *p,p'*-DDE + *o,p'*-TDE + *p,p'*-TDE).
[2] Residues confirmed by combined gas chromatography—mass spectrometry.
[3] Confirmation accomplished by Coulson conductivity conductor and thin-layer chromatography.
[4] Residue levels were below instrument sensitivity and could not be confirmed.
[5] Presence of PCB's represents exposure to these industrial chemicals.

pressing total body burden of these chemicals as DDT. This equivalent, with a mean of 0.344 ppm, represents the insecticide found in the greatest concentration.

In the milk analyzed, 73.7 percent of the Σ DDT equivalent burden was found as DDE. Of the DDT transformation products found in the human milk, *p,p'*-DDT and *p,p'*-DDE were apparent at mean levels of 0.092 ppm and 0.227 ppm, respectively. The presence of these metabolites was confirmed by Coulson electrolytic conductivity detector, thin-layer chromatography, and combined GC-MS. There was a single observation of *p,p'*-TDE at 0.02 ppm. Trace quantities of *o,p'*-DDT were present in all 57 samples; *o,p'*-TDE and *o,p'*-DDE were not detected.

The presence of β-BHC residues indicate exposure to insecticides containing benzene hexachloride. This chemical appeared in at least trace amounts in all milk analyzed at a mean value of 0.005 ppm. The α, γ (lindane), and δ isomers of BHC were not detected.

Since aldrin is quickly epoxidized to dieldrin, dieldrin residues signify exposure to either or both of these pesticides. Quantifiable residues of dieldrin were detected in 28.1 percent of the samples at a mean concentration of 0.004 ppm.

Oxychlordane is a major mammalian metabolite of the insecticides chlordane and heptachlor. Along with heptachlor epoxide and *trans*-nonachlor, which also indicate exposure to heptachlor and chlordane, it was found in quantifiable or trace amounts in every milk sample analyzed. Oxychlordane and heptachlor epoxide were present at mean levels of 0.005 ppm and 0.004 ppm, respectively. The compound *trans*-nonachlor, one of several that comprise technical chlordane and technical heptachlor, was first reported in human adipose tissue in a recent study by Kutz et al. (*4*). This compound had a mean level of 0.001 ppm in the human milk sampled. Oxychlordane was qualitatively confirmed by combined GC-MS; levels of heptachlor epoxide and *trans*-nonachlor were below instrument sensitivity and, consequently, could not be confirmed.

To the authors' knowledge, this is the first report of the occurrence of oxychlordane and *trans*-nonachlor in human milk. Save et al. (*8*) and Curley and Kimbrough (*1,2*) have reported residue levels of heptachlor epoxide, dieldrin, BHC, DDT, and PCB's.

Acknowledgments

Authors gratefully acknowledge the assistance of the following persons with the analytical portion of this study:

U.S. ENVIRONMENTAL PROTECTION AGENCY
G. Wayne Sovocool, Analytical Chemistry Branch, Environmental Toxicology Division, Health Effects Research Laboratory, Research Triangle Park, N.C.; Ronald F. Thomas, Chemical and Biological Investigations Branch, Technical Services Division, Beltsville, Md.; Jack Thompson, Quality Assurance Section, Analytical Chemistry Branch, Environmental Toxicology Division, Human Effects Research Laboratory, Research Triangle Park, N.C.

MICHIGAN DEPARTMENT OF PUBLIC HEALTH
Robert L. Welch, Pesticide Epidemiologic Studies Project, Lansing, Mich.

LITERATURE CITED

(*1*) *Curley, A., M. F. Copeland, and R. D. Kimbrough. 1969.* Chlorinated hydrocarbon insecticides in organs of stillborn and blood of newborn babies. Arch. Environ. Health 19(5):628-632.

(*2*) *Curley, A., and R. Kimbrough. 1969.* Chlorinated hydrocarbon insecticides in plasma and milk of pregnant and lactating women. Arch. Environ. Health 18(2):156-164.

(*3*) *Giuffrida, L., D. C. Bostwick, and N. F. Ives. 1966.* Rapid cleanup techniques for chlorinated pesticide residues in milk, fats, and oils. J. Assoc. Off. Anal. Chem. 49(3):634-638.

(*4*) *Kutz, F. W., W. Sovocool, S. Strassman, and R. G. Lewis. 1977. trans*-Nonachlor residues in human adipose tissue. Bull. Environ. Contam. Toxicol. 16(1):9-14.

(*5*) Kutz, F. W., A. R. Yobs, W. G. Johnson, and G. B. Wiersma. 1974. Pesticide residues in adipose tissue of the general population of the United States, FY 1970 survey. Bull. Soc. Pharmacol. Environ. Pathol. 2(3):4-10.

(*6*) *Morgan, D. P., and C. D. Roan. 1971.* Absorption, storage, and metabolic conversion of ingested DDT and DDT metabolites in man. Arch. Environ. Health 22(3):309-315.

(*7*) *O'Leary, J. A., J. E. Davies, W. F. Edmundson, and G. A. Reich. 1970.* Transplacental passage of pesticides. Am. J. Obstet. Gynecol. 107(1):65-68.

(*8*) *Savage, E. P., J. D. Tessari, J. W. Malberg, W. H. Wheeler, and J. R. Bagby. 1973.* Organochlorine pesticide residues and polychlorinated biphenyls in human milk, Colorado—1971-72. Pestic. Monit. J. 7(1):1-5.

(*9*) *Su, G. C., and H. A. Price. 1973.* Element specific gas chromatographic analyses of organochlorine pesticides in the presence of PCB's by selective cancellation of interfering peaks. J. Agric. Food Chem. 21(6):1099-1102.

(*10*) *Thompson, J. F. (ed.). 1972.* Analysis of Pesticide Residues in Human and Environmental Samples. Prepared by EPA Environmental Toxicology Division, Research Triangle Park, N.C.

(*11*) *Yobs, A. R. 1971.* The National Human Monitoring Program for Pesticides. Pestic. Monit. J. 5(1):44-46.

RESIDUES IN FOOD AND FEED

Pesticide and Other Chemical Residues in Total Diet Samples (X)

D. D. Manske and R. D. Johnson[1]

ABSTRACT

Since 1964 the Food and Drug Administration Total Diet study has reported residues of pesticides and other chemicals ingested in the diet of a young adult male, statistically the Nation's largest eater. During the tenth year of the study, pesticide residues remained at the relatively low levels previously reported. Thirty market baskets were collected in 30 cities which ranged in population from less than 50,000 to 1,000,000 or more. Averages and ranges of residues are reported from August 1973 through July 1974 by food class. Individual items in the dairy and meat composites in four market baskets were analyzed for pesticides; results are included. Data for lead, cadmium, selenium, mercury, arsenic, and zinc are also included. Results of recovery studies within various classes of residues are also presented.

Introduction

The Food and Drug Administration Total Diet Program (*10*), sometimes called the Market Basket study, began with a program intended for surveillance of fission products from atmospheric tests of thermonuclear weapons in May 1961. The program was quickly extended to pesticides and certain nutrients (*10*). Although some changes have been made in sampling frequency, areas sampled, analytical methods used, and types of residues sought, the program has continued in essentially the same form to the present. A market basket of food representing the basic 2-week diet of a 16- to 19-year-old male, statistically the Nation's largest eater, is collected in each of several geographic areas. The various foods are prepared in the manner in which they would normally be served and eaten. Foods in each of 12 broad classes are composited into a slurry and analyzed for the presence of organochlorine pesticides, organophosphorous pesticides, carbaryl, herbicides, certain metals, and polychlorinated biphenyls (PCB's). Methodology includes atomic absorption spectroscopy, fluorometry, gas chromatography, thin-layer chromatography, and established extraction and cleanup techniques. Conditions, techniques, and limits of quantitation have been described in previous reports of the series (*1-6, 13-15, 19*. Also: H. K. Hundley and J. C. Underwood, Food and Drug Administration, 1970: personal communication). Amounts and types of residues found from June 1964 through July 1973 have also been described in earlier reports (*7-9, 11, 12, 15-18*). The present report presents results obtained from August 1973 through July 1974. Samples were collected in 30 different grocery markets in 30 different cities.

Results

During this reporting period 1,613 residues of 42 different compounds were found in the 360 composites examined. In the previous reporting period, 1,729 residues of 40 different compounds had been found. The 42 different residues found are listed in decreasing order of frequency in Table 1. In Table 2, the frequency of occurrence of these residues is broken down according to food class. Table 3 gives the levels of the chemical residues by food class. The average stated in Table 3 is based on 30 composites examined; any trace residues have not been included in calculating the average. For this reason, an average value reported as "T" can be well below the detection limits of the method for that compound.

The most common residues and their maximum levels are disucssed below for each of the 12 classes of food composites. No findings have been corrected for recoveries obtained in recovery experiments. A summary of recovery studies appears in Table 4.

DAIRY PRODUCTS

Organochlorine compounds were the most frequently found residues in dairy products. The most common organochlorines were dieldrin, 0.0050 ppm; BHC, 0.0030 ppm; DDE, 0.010 ppm; and heptachlor epoxide, 0.0020 ppm. Other organochlorine residues present were DDT, lindane, TDE, methoxychlor, HCB, and PCP. Zinc,

1 Kansas City Field Office Laboratory, Food and Drug Administration, U.S. Department of Health, Education, and Welfare, Kansas City, Mo. 64106.

ranging from 4.0 to 8.6 ppm, was found in all 30 composites. Selenium, cadmium, and lead were occasionally found in this food class. No organophosphorous residues were detected.

MEAT, FISH, AND POULTRY

Nine organochlorine compounds occurred in varying combinations in all 30 composites. The most common were DDE, 0.038 ppm; dieldrin, 0.033 ppm; DDT, 0.020 ppm; BHC, 0.0070 ppm; TDE, 0.005 ppm; and heptachlor epoxide, 0.0040 ppm. Other residues were lindane, PCB, HCB, ronnel, diazinon, and ethion. Mercury, selenium, and zinc, ranging from trace to 0.04 ppm, 0.1 to 0.4 ppm, and 21.0 to 35.5 ppm, respectively, were found in all 30 composites. Cadmium, arsenic, and lead were also found.

GRAIN AND CEREAL PRODUCTS

Malathion, ranging from 0.004 to 0.054 ppm, was found in all 30 composites. Selenium and zinc, ranging from 0.10 to 0.40 ppm and 5.9 to 10.1 ppm, respectively, were found in all 30 composites. Other residues included diazinon, BHC, DDT, PCA, chlordane, heptachlor, cadmium, and lead.

POTATOES

Zinc, ranging from 1.8 to 7.5 ppm, was found in all 30 composites. Of the ten organochlorine residues which appeared in this composite, the most common were CIPC, 0.467 ppm; dieldrin, 0.007 ppm; and DDE, 0.012 ppm. Other residues were endosulfan, DDT, TCNB, TDE, heptachlor epoxide, diazinon, HCB, PCNB, cadmium, lead, selenium, and mercury.

LEAFY VEGETABLES

Organophosphates were the most frequently detected pesticide residues in leafy vegetables. The most common were diazinon, 0.015 ppm; parathion, 0.022 ppm; and methyl parathion, 0.008 ppm. All 30 composites contained zinc ranging from 0.8 to 4.1 ppm. Cadmium, ranging from 0.01 to 0.14 ppm, was found in 28 composites, and lead, ranging from 0.03 to 0.40 ppm, was found in 20 composites. Less frequently occurring residues were endosulfan, DDE, malathion, selenium, dieldrin, perthane, DDT, DCPA, botran, nitrofen, lindane, and mercury.

LEGUME VEGETABLES

Zinc and lead, ranging from 5.0 to 14.5 ppm and 0.10 to 1.30 ppm, respectively, were found in all 30 composites. Other residues were cadmium, selenium, HCB, and carbaryl.

ROOT VEGETABLES

Zinc, ranging from 1.4 to 5.0 ppm, was found in all 30 composites. Twenty-four composites contained cadmium with a maximum level of 0.31 ppm, and 22 composites contained lead with a maximum level of 0.30 ppm. Other residues were selenium, arsenic, DDE, lindane, diazinon, TDE, HCB, parathion, and PCP.

GARDEN FRUITS

The most common pesticide residues in this composite were dieldrin, 0.015 ppm; lindane, 0.004 ppm; BHC, 0.005 ppm; diazinon, 0.003 ppm; and leptophos, 0.090 ppm. Thirty composites contained zinc ranging from 2.1 to 4.8 ppm. Other residues were cadmium, lead, selenium, DDE, DDT, arsenic, endosulfan, parathion, carbaryl, perthane, and toxaphene.

FRUITS

The nonmetallic residues most frequently encountered in fruits were carbaryl, 0.10 ppm; orthophenylphenol, 0.20 ppm; and ethion, 0.012 ppm. Zinc, ranging from 0.1 to 3.0 ppm, was found in all 30 composites. Other residues were lead, cadmium, selenium, dieldrin, diazinon, mercury, arsenic, parathion, botran, dicofol, aldrin, and phosalone.

OILS, FATS, AND SHORTENING

The most common residues were malathion, 0.115 ppm, and PCA, 0.050 ppm. Zinc, ranging from 3.6 to 8.4 ppm, was found in all 30 composites. Other residues were cadmium, lead, selenium, dieldrin, DDE, BHC, DDT, lindane, TDE, HCB, parathion, TCNB, PCNB, and captan.

SUGARS AND ADJUNCTS

The most frequently found organochlorine residues were lindane, 0.008 ppm; BHC, 0.002 ppm; and PCP, 0.033 ppm. Thirty composites contained zinc ranging from 1.5 ppm to 6.4 ppm. Other residues included cadmium, lead, selenium, mercury, malathion, diazinon, PCB, and orthophenylphenol.

BEVERAGES

No organochlorine or organophosphates were found in any of the 30 beverage composites examined. Zinc, ranging from 0.3 to 1.3 ppm, was found in all 30 composites. Other metallic residues were cadmium, lead, and selenium.

Discussion

Of the 360 composites examined, organochlorine residues were found in 172, or 48 percent. Corresponding findings from previous years were 52 percent, 1972-73; 54 percent, 1971-72; and 61.4 percent, 1970-71. Organophosphorus residues in the current reporting period were found in 100 composites, or 28 percent. Corresponding findings in

previous years were 31, 27.8, and 21.4 percent, respectively.

Carbaryl occurred in eight composites during this reporting period; four of these findings were at trace levels. This is below the 12 findings in the previous reporting period. Orthophenylphenol, which is detected by the method used for carbaryl, was found in five composites; two of these findings represented trace levels. Only one composite revealed orthophenylphenol in the previous reporting period.

No chlorophenoxy acid herbicides appeared in this reporting period. Pentachlorophenol, which is detected by the method used for chlorophenoxy acids, was found 10 times. Seven of these findings occurred in Composite XI, sugars and adjuncts. Analysis of the individual commodities in this composite showed the source of the pentachlorophenols to be candy bars.

Zinc appeared in all composites ranging from 0.1 to 35.5 ppm. The second most commonly occurring metal, cadmium, was found in all 12 food classes. It occurred in 211 of the 360 composites examined at levels ranging from 0.01 to 0.31 ppm. Lead and selenium were also found in all 12 food classes. The highest of the 180 findings of lead was 1.30 ppm, and the highest of the 97 findings of selenium was 0.40 ppm. Mercury occurred in 34 composites; meat, fish, and poultry contributed 30 of those findings. The highest mercury residue was 0.04 ppm.

The individual commodity analysis for chlorinated, organophosphate, and PCP residues on food groups I (dairy) and II (meats) that began last reporting period was continued on four samples of this period's 30 Total Diet samples. Composites I and II were selected because they had had the most significant occurrence of chlorinated residues in previous analyses. Individual commodity analysis results are shown for dairy products in Table 5 and for meat, fish, and poultry in Table 6. Three items from the dairy group, namely, buttermilk, skim milk, and nonfat dry milk, and one item from the meat group, shrimp, are not shown because they contained no residues.

Recovery studies were conducted for all classes of chemicals sought throughout the entire year (Table 4). Each recovery experiment consisted of a single determination for the unfortified food composite and a single determination for the fortified sample. Because these were performed simultaneously, the fortification level occasionally was below the level present in the sample. In other cases, not enough recoveries were run to permit statistical evaluation. These data are not reported.

At very low fortification levels, recoveries may range from 0 to 200 percent. As the fortification level is raised, however, recovery improves. Recovery data indicate that individual, low-level residues reported may vary from the so-called true value but the overall findings are useful in appraising the national residue picture.

LITERATURE CITED

(1) *Association of Official Analytical Chemists. 1975.* Official Methods of Analysis, 12th ed. Washington, D.C. Sections 25.012-25.013.

(2) *Association of Official Analytical Chemists. 1975.* Official Methods of Analysis, 12th ed. Washington, D.C. Sections 25.026-25.030.

(3) *Association of Official Analytical Chemists. 1975.* Official Methods of Analysis, 12th ed. Washington, D.C. Sections 25.065-25.070.

(4) *Association of Official Analytical Chemists. 1975.* Official Methods of Analysis, 12th ed. Washington, D.C. Sections 25.103-25.105.

(5) *Association of Official Analytical Chemists. 1975.* Official Methods of Analysis, 12th ed. Washington, D.C. Sections 25.117-25.120.

(6) *Association of Official Analytical Chemists. 1975.* Official Methods of Analysis, 12th ed. Washington, D.C. Sections 25.143-25.147.

(7) *Corneliussen, P. E. 1969.* Pesticide residues in total diet samples (IV). Pestic. Monit. J. 2(4):140-152.

(8) *Corneliussen, P. E. 1970.* Pesticide residues in total diet samples (V). Pestic. Monit. J. 4(3):89-105.

(9) *Corneliussen, P.E. 1972.* Pesticide residues in total diet samples (VI). Pestic. Monit. J. 5(4):313-330.

(10) *Duggan, R.E., and F. J. McFarland. 1967.* Assessments include raw food and feed commodities, market basket items prepared for consumption, meat samples taken at slaughter. Pestic. Monit. J. 1(1):1-5.

(11) *Duggan, R. E., H. C. Barry, and L. Y. Johnson. 1966.* Pesticide residues in total diet samples. Science 151 (3706):101-104.

(12) *Duggan, R. E., H. C. Barry, and L. Y. Johnson, 1967.* Pesticide residues in total diet samples (II). Pestic. Monit. J. 1(2):2-12.

(13) *Finocchiaro, J.M., and W. R. Benson. 1965.* Thin-layer chromatographic determination of carbaryl (Sevin) in some foods. J. Assoc. Offic. Anal. Chem. 48(4):736-738.

(14) *Food and Drug Administration. 1971.* Pesticide Analytical Manual, Vol. I and II. U.S. Department of Health, Education, and Welfare.

(15) *Johnson, R.D., and D. D. Manske. 1975.* Pesticide residues in total diet samples (IX). Pestic. Monit. J. 9(4):157-169.

(16) *Manske, D.D., and P. E. Corneliussen. 1974.* Pesticide residues in total diet samples (VII). Pestic. Monit. J. 8(2):110-124.

(17) *Manske, D. D., and R. D. Johnson. 1975.* Pesticide

residues in total diet samples (VIII). Pestic. Monit. J. 9(2):94-105.

(18) *Martin, R. J., and R. E. Duggan. 1968.* Pesticide residues in total diet samples (III). Pestic. Monit. J. 1(4):11-20.

(19) *Porter, M. L., R. J. Gajan, and J. A. Burke. 1969.* Acetonitrile extraction and determination of carbaryl in fruits and vegetables. J. Assoc. Offic. Anal. Chem. 52(1):177-181.

TABLE 1. *Chemical residues found in food composites, August 1973-July 1974*

Chemical	No. Composities With Residues	No. Positive Composites With Residues Reported As Trace [1]	Range, ppm
ZINC	360	0	0.1-35.5
CADMIUM	211	0	0.01-0.31
LEAD	180	0	0.02-1.30
SELENIUM	97	34	0.05-0.40
DIELDRIN Not less than 85% of 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-exo-5,8-dimethanonaphthalene	93	17	0.0006-0.0330
DDE 1,1-dichloro-2,2-bis (p-chlorophenyl) ethylene (all isomers are included in reportings)	81	20	0.0006-0.0380
BHC 1,2,3,4,5,6-hexachlorocyclohexane, mixed isomers except gamma	76	12	0.0004-0.0070
DDT 1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane (isomers other than p,p' also included in reportings)	54	15	0.002-0.020
MALATHION diethylmercaptosuccinate, S-ester with 0,0-dimethyl phosphorodithioate	53	6	0.003-0.115
LINDANE 1,2,3,4,5,6-hexachlorocyclohexane, 99% or more gamma isomer	52	18	0.0003-0.0120
DIAZINON 0,0-diethyl o-(2-isopropyl-6-methyl-4-pyrimidyl) phosphorothioate	50	20	0.0007-0.0270
HEPTACHLOR EPOXIDE 1,4,5,6,7,8,8-heptachloro-2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-endo-methanoindan	46	19	0.0005-0.0040
TDE 1,1-dichloro-2,2-bis (p-chlorophenyl) ethane (isomers other than p,p' also included in reportings)	3	23	0.001-0.005
MERCURY	34	17	0.01-0.04
ARSENIC (As_2O_3)	18	2	0.03-0.60
ENDOSULFAN 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin 3-oxide (reportings include isomers I, II, and the sulfate)	17	10	0.003-0.012
HCB Hexachlorobenzene	17	8	0.0003-0.0070
PARATHION O,O-diethyl O-p-nitrophenyl phosphorothioate	17	10	0.003-0.022
PCB (polychlorinated biphenyls) calculated as Aroclor with varied chlorine content	14	13	0.050
CIPC isopropyl n-(3-chlorophenyl) carbamate	12	0	0.005-0.467
PCA pentachloroaniline	10	1	0.004-0.050
PCP pentachlorophenol	10	0	0.010-0.033
CARBARYL 1-naphthyl methyl carbamate	8	4	0.05-0.50
TCNB 1,2,4,5-tetrachloro-3-nitrobenzene	8	2	0.001-0.284
METHOXYCHLOR 1,1,1-trichloro-2,2-bis (p-methoxyphenyl) ethane	7	2	0.004-0.009
METHYL PARATHION O,O-dimethyl O-p-nitrophenyl phosphorothioate	7	6	0.008
PCNB pentachloronitrobenzene	7	4	0.002-0.005
ETHION O,O,O',O'-tetraethyl S,S'-methylene bisphosphorodithioate	6	3	0.003-0.012
ORTHOPHENYLPHENOL 2-hydroxydiphenyl	5	2	0.05-0.20
LEPTOPHOS O-(2,5-dichloro-4-bromophenyl)-O-methylphenyl phosphorothioate	5	1	0.013-0.090

(Continued next page)

TABLE 1 (cont'd.). *Chemical residues found in food composites, August 1973—July 1974*

Chemical	No. Composities With Residues	No. Positive Composites With Residues Reported As Trace [1]	Range, ppm
PERTHANE 1,1-dichloro-2,2-bis (p-ethylphenyl) ethane	4	0	0.030-2.28
BOTRAN 2,6-dichloro-4-nitroaniline	3	0	0.006-0.067
TOXAPHENE chlorinated camphene containing 67 to 69% chlorine	3	2	0.163
DCPA (DACTHAL) 2,3,5,6-tetrachloroterephthalic acid dimethyl ester	2	0	0.003-0.013
DICOFOL (KELTHANE) 4,4'-dichloro-α-(trichloromethyl) benzhydrol	2	1	0.010
ALDRIN Not less than 95% of 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo-exo-5,8-dimethanonaphthalene	1	0	0.001
CAPTAN N-[(trichloromethyl)thio] -4-cyclohexene-1,2-dicarboximide	1	0	0.178
CHLORDANE (Technical) Cis and trans isomers of 1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-4,7-methanoindane plus approximately 50% related compounds	1	1	T
HEPTACHLOR 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-endo-methanoindene	1	0	0.004
PHOSALONE O,O-diethyl S-(6-chloro-2-oxobenzoxazolin-3-yl) methyl phosphorodithioate	1	0	0.171
RONNEL O,O-dimethyl (O-2,4,5-trichlorophenyl) phosphorothioate	1	0	0.001
NITROFEN 2,4-dichlorophenyl-p-nitrophenyl ether	1	0	0.039

[1] Chemicals detectable by the specific analytical methodology can be confirmed qualitatively but are not quantifiable in concentrations below the limit of quantitation. Limit of quantitation varies with residue and food class.

TABLE 2. *Occurrence frequency of chemical residues by food class, August 1973—July 1974*

Chemical	Food Class[1]											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Number of Occurrences											
Zinc	30	30	30	30	30	30	30	30	30	30	30	30
Cadmium	4	21	29	29	28	8	24	23	3	24	12	6
Lead	4	9	11	13	20	30	22	26	23	8	9	5
Selenium	10	30	30	5	3	5	3	2	1	3	3	2
Dieldrin	29	30		9	3			17	2	3		
DDE	27	30		9	4		7	2		2		
BHC	29	27	1					6		4	9	
DDT	10	29	1	8	1			1		4		
Malathion			30		4					16	3	
Lindane	10	19			1		3	6		2	11	
Diazinon		6	16	3	17		1	5	1		1	
Heptachlor Epoxide	22	22		2								
TDE	8	25		2			1			2		
Mercury		30		1	1				1		1	
Arsenic		10					2	1	5			
Endosulfan				6	8			3				
HCB	3	4		1		1	1			7		
Parathion					11		3	1	1	1		
PCB		13									1	
CIPC				12								
PCA										10		
PCP	1		1				1				7	
Carbaryl						1		1	6			
TCNB				6						2		
Methoxychlor	7											
Methyl Parathion					7							
PCNB				1						6		
Ethion		1							5			
Orthophenylphenol									4		1	
Leptophos								5				
Perthane*					3			1				
Botran*					1				2			
Toxaphene								3				
DCPA					2							

(Continued next page)

TABLE 2 (cont'd.). *Occurrence frequency of chemical residues by food class, August 1973—July 1974*

Chemical	Food Class[1]											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Number of Occurrences											
Dicofol									2			
Aldrin									1			
Captan										1		
Chlordane			1									
Heptachlor			1									
Phosalone									1			
Ronnel		1										
Nitrofen					1							

[1] See Table 3 for descriptions of food classes.

Table 3. *Levels of chemical residues found—by food class in 30 composites, August 1973—July 1974*

	Residues, ppm
I. Dairy Products	
ZINC	
Average	5.5
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	4.0–8.6
BHC	
Average	0.0008
Positive Composites	
Total Number	29
Number Reported as Trace	2
Range	0.0004–0.0030
DIELDRIN	
Average	0.0016
Positive Composites	
Total Number	29
Number Reported as Trace	3
Range	0.0006–0.0050
DDE	
Average	0.0015
Positive Composites	
Total Number	27
Number Reported as Trace	9
Range	0.0006–0.0100
HEPTACHLOR EPOXIDE	
Average	0.0004
Positive Composites	
Total Number	22
Number Reported as Trace	10
Range	0.0005–0.0020
DDT	
Average	0.0003
Positive Composites	
Total Number	10
Number Reported as Trace	8
Range	0.003–0.006
LINDANE	
Average	0.0002
Positive Composites	
Total Number	10
Number Reported as Trace	6
Range	0.0003–0.0028
SELENIUM	
Average	T
Positive Composites	
Total Number	10
Number Reported as Trace	9
Range	0.07
TDE	
Average	T
Positive Composites	
Total Number	8
Number Reported as Trace	8
Range	T
METHOXYCHLOR	
Average	0.001
Positive Composites	
Total Number	7
Number Reported as Trace	2
Range	0.004–0.03
CADMIUM	
Average	0.01
Positive Composites	
Total Number	4
Number Reported as Trace	0
Range	0.01–0.14
LEAD	
Average	0.01
Positive Composites	
Total Number	4
Number Reported as Trace	0
Range	0.04–0.08
HCB	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	1
Range	0.0003–0.0006
PCP	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.010
II. Meat, Fish, And Poultry	
DDE	
Average	0.0085
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	0.002–0.038
DIELDRIN	
Average	0.0056
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	0.002–0.033
TDE	
Average	0.002
Positive Composites	
Total Number	25
Number Reported as Trace	11
Range	0.001–0.005
HEPTACHLOR EPOXIDE	
Average	0.001
Positive Composites	
Total Number	22
Number Reported as Trace	8
Range	0.001–0.004

(Continued next page)

TABLE 3 (cont'd.). *Levels of chemical residues found—by food class in 30 composites, August 1973—July 1974*

	Residues, ppm
II. Meat, Fish, And Poultry	
MERCURY	
Average	0.01
Positive Composites	
Total Number	30
Number Reported as Trace	13
Range	0.01–0.04
SELENIUM	
Average	0.20
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	0.10–0.40
ZINC	
Average	28.0
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	21.0–35.5
DDT	
Average	0.006
Positive Composites	
Total Number	29
Number Reported as Trace	0
Range	0.002–0.020
BHC	
Average	0.0011
Positive Composites	
Total Number	27
Number Reported as Trace	1
Range	0.0004–0.0070
DIAZINON	
Average	0.0001
Positive Composites	
Total Number	6
Number Reported as Trace	3
Range	0.0007–0.0010
HCB	
Average	T
Positive Composites	
Total Number	4
Number Reported as Trace	2
Range	0.0003–0.0006
CADMIUM	
Average	0.02
Positive Composites	
Total Number	21
Number Reported as Trace	0
Range	0.01–0.06
LINDANE	
Average	0.0010
Positive Composites	
Total Number	19
Number Reported as Trace	3
Range	0.0004–0.0120
PCB	
Average	0.002
Positive Composites	
Total Number	13
Number Reported as Trace	12
Range	0.050
ARSENIC	
Average	0.06
Positive Composites	
Total Number	10
Number Reported as Trace	1
Range	0.03–0.6
LEAD	
Average	0.02
Positive Composites	
Total Number	9
Number Reported as Trace	0
Range	0.03–0.10
ETHION	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.001
RONNEL	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.0010
III. Grain And Cereal Products	
MALATHION	
Average	0.020
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	0.004–0.054
SELENIUM	
Average	0.24
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	0.10–0.40
ZINC	
Average	8.1
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	5.9–10.1
CADMIUM	
Average	0.03
Positive Composites	
Total Number	29
Number Reported as Trace	0
Range	0.02–0.05
DDT	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
DIAZINON	
Average	0.002
Positive Composites	
Total Number	16
Number Reported as Trace	7
Range	0.002–0.011
LEAD	
Average	0.03
Positive Composites	
Total Number	11
Number Reported as Trace	0
Range	0.03–0.2
BHC	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.006
CHLORDANE	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
PCP	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.017

(Continued next page)

TABLE 3 (cont'd.). *Levels of chemical residues found—by food class in 30 composites, August 1973—July 1974*

Residues, ppm	
III. Grain And Cereal Products	
HEPTACHLOR	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.004
IV. Potatoes	
ZINC	
Average	4.5
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	1.8–7.5
CADMIUM	
Average	0.05
Positive Composites	
Total Number	29
Number Reported as Trace	0
Range	0.02–0.13
LEAD	
Average	0.03
Positive Composites	
Total Number	13
Number Reported as Trace	0
Range	0.02–0.10
CIPC	
Average	0.047
Positive Composites	
Total Number	12
Number Reported as Trace	0
Range	0.005–0.467
TCNB	
Average	0.010
Positive Composites	
Total Number	6
Number Reported as Trace	0
Range	0.001–0.284
SELENIUM	
Average	T
Positive Composites	
Total Number	5
Number Reported as Trace	5
Range	T
DIAZINON	
Average	0.001
Positive Composites	
Total Number	3
Number Reported as Trace	2
Range	0.027
HEPTACHLOR EPOXIDE	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	1
Range	0.002
DDE	
Average	0.001
Positive Composites	
Total Number	9
Number Reported as Trace	3
Range	0.002–0.012
DIELDRIN	
Average	0.001
Positive Composites	
Total Number	9
Number Reported as Trace	3
Range	0.002–0.007
DDT	
Average	0.001
Positive Composites	
Total Number	8
Number Reported as Trace	4
Range	0.005–0.008
ENDOSULFAN	
Average	0.001
Positive Composites	
Total Number	6
Number Reported as Trace	3
Range	0.005–0.016
TDE	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	2
Range	T
HCB	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.004
MERCURY	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
PCNB	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.005
V. Leafy Vegetables	
ZINC	
Average	2.4
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	0.8–4.1
CADMIUM	
Average	0.04
Positive Composites	
Total Number	28
Number Reported as Trace	0
Range	0.01–0.14
PARATHION	
Average	0.002
Positive Composites	
Total Number	11
Number Reported as Trace	6
Range	0.004–0.022
LEAD	
Average	0.10
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	0.03–0.4
DIAZINON	
Average	0.002
Positive Composites	
Total Number	17
Number Reported as Trace	5
Range	0.001–00
SELENIUM	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	3
Range	T

(Continued next page)

TABLE 3 (cont'd.). *Levels of chemical residues found—by food class in 30 composites, August 1973—July 1974*

	Residues, ppm
V. Leafy Vegetables	
ENDOSULFAN	
Average	0.001
Positive Composites	
Total Number	8
Number Reported as Trace	4
Range	0.003–0.012
METHYL PARATHION	
Average	T
Positive Composites	
Total Number	7
Number Reported as Trace	6
Range	0.008
DDE	
Average	T
Positive Composites	
Total Number	4
Number Reported as Trace	1
Range	0.003–0.005
MALATHION	
Average	T
Positive Composites	
Total Number	4
Number Reported as Trace	2
Range	0.005–0.006
DIELDRIN	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	3
Range	T
PERTHANE	
Average	0.13
Positive Composites	
Total Number	3
Number Reported as Trace	0
Range	0.03–2.28
DCPA	
Average	0.001
Positive Composites	
Total Number	2
Number Reported as Trace	0
Range	0.003–0.013
BOTRAN	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.008
DDT	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.015
LINDANE	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
MERCURY	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
NITROFEN	
Average	0.001
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.039
VI. Legume Vegetables	
LEAD	
Average	0.28
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	0.10–1.30
ZINC	
Average	8.5
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	5.0–14.5
CADMIUM	
Average	0.01
Positive Composites	
Total Number	8
Number Reported as Trace	0
Range	0.01–0.10
SELENIUM	
Average	T
Positive Composites	
Total Number	5
Number Reported as Trace	4
Range	0.05
CARBARYL	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.5
HCB	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
VII. Root Vegetables	
ZINC	
Average	2.8
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	1.4–5.0
CADMIUM	
Average	0.03
Positive Composites	
Total Number	24
Number Reported as Trace	0
Range	0.01–0.31
LEAD	
Average	0.09
Positive Composites	
Total Number	22
Number Reported as Trace	0
Range	0.03–0.30
DDE	
Average	T
Positive Composites	
Total Number	7
Number Reported as Trace	4
Range	0.003–0.00
LINDANE	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	1
Range	0.003–0.00
PARATHION	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	3
Range	T

(Continued next page)

TABLE 3 (cont'd.). *Levels of chemical residues found—by food class in 30 composites, August 1973—July 1974*

	Residues, ppm
VII. Root Vegetables	
SELENIUM	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	3
Range	T
ARSENIC	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	0
Range	0.03–0.1
DIAZINON	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
HCB	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.002
PCP	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.01
TDE	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.004
VIII. Garden Fruits	
ZINC	
Average	3.0
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	2.1–4.8
LEAD	
Average	0.14
Positive Composites	
Total Number	26
Number Reported as Trace	0
Range	0.06–0.60
CADMIUM	
Average	0.02
Positive Composites	
Total Number	23
Number Reported as Trace	0
Range	0.01–0.10
DIAZINON	
Average	T
Positive Composites	
Total Number	5
Number Reported as Trace	2
Range	0.002–0.003
LEPTOPHOS	
Average	0.005
Positive Composites	
Total Number	5
Number Reported as Trace	1
Range	0.013–0.090
ENDOSULFAN	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	3
Range	T
TOXAPHENE	
Average	0.005
Positive Composites	
Total Number	3
Number Reported as Trace	2
Range	0.163
DDE	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	2
Range	T
SELENIUM	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	2
Range	T
DIELDRIN	
Average	0.002
Positive Composites	
Total Number	17
Number Reported as Trace	4
Range	0.002–0.01
BHC	
Average	0.0003
Positive Composites	
Total Number	6
Number Reported as Trace	3
Range	0.0009–0.00
LINDANE	
Average	T
Positive Composites	
Total Number	6
Number Reported as Trace	4
Range	0.002–0.004
ARSENIC	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.04
CARBARYL	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
DDT	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.011
PARATHION	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.006
PERTHANE	
Average	0.001
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.031

(Continued next page)

TABLE 3 (cont'd.). *Levels of chemical residues found—by food class in 30 composites, August 1973—July 1974*

	Residues, ppm
IX. Fruits	
ZINC	
Average	1.1
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	0.1–3.0
CARBARYL	
Average	0.01
Positive Composites	
Total Number	6
Number Reported as Trace	3
Range	0.05–0.10
ARSENIC	
Average	0.02
Positive Composites	
Total Number	5
Number Reported as Trace	1
Range	0.03–0.20
ETHION	
Average	0.001
Positive Composites	
Total Number	5
Number Reported as Trace	3
Range	0.005–0.012
ORTHOPHENYLPHENOL	
Average	0.02
Positive Composites	
Total Number	4
Number Reported as Trace	1
Range	0.05–0.20
CADMIUM	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	0
Range	0.01–0.06
BOTRAN	
Average	0.002
Positive Composites	
Total Number	2
Number Reported as Trace	0
Range	0.006–0.067
DICOFOL	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	1
Range	0.01
LEAD	
Average	0.10
Positive Composites	
Total Number	23
Number Reported as Trace	0
Range	0.04–0.44
DIELDRIN	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	2
Range	T
ALDRIN	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.001
DIAZINON	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0.
Range	0.003
MERCURY	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
PARATHION	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.003
PHOSALONE	
Average	0.006
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.171
SELENIUM	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
X. Oils, Fats, And Shortening	
ZINC	
Average	5.1
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	3.6–8.4
CADMIUM	
Average	0.02
Positive Composites	
Total Number	24
Number Reported as Trace	0
Range	0.01–0.07
MALATHION	
Average	0.015
Positive Composites	
Total Number	16
Number Reported as Trace	4
Range	0.011–0.115
PCA	
Average	0.004
Positive Composites	
Total Number	10
Number Reported as Trace	1
Range	0.004–0.050
BHC	
Average	T
Positive Composites	
Total Number	4
Number Reported as Trace	3
Range	0.003
DDT	
Average	0.001
Positive Composites	
Total Number	4
Number Reported as Trace	2
Range	0.009–0.011
DIELDRIN	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	2
Range	0.004
SELENIUM	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	2
Range	0.05

(Continued next page)

TABLE 3 (cont'd.). *Levels of chemical residues found—by food class in 30 composites, August 1973—July 1974*

Residues, ppm	
X. Oils, Fats, And Shortening	
LEAD	
Average	0.03
Positive Composites	
Total Number	8
Number Reported as Trace	0
Range	0.03–0.40
HCB	
Average	T
Positive Composites	
Total Number	7
Number Reported as Trace	4
Range	0.001–0.007
PCNB	
Average	T
Positive Composites	
Total Number	6
Number Reported as Trace	4
Range	0.002–0.005
TDE	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	2
Range	T
CAPTAN	
Average	0.006
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.178
DDE	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	1
Range	0.004
LINDANE	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	1
Range	0.002
TCNB	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	2
Range	T
PARATHION	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
XI. Sugars And Adjuncts	
ZINC	
Average	3.0
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	1.5–6.4
CADMIUM	
Average	0.01
Positive Composites	
Total Number	12
Number Reported as Trace	0
Range	0.01–0.09
LINDANE	
Average	T
Positive Composites	
Total Number	11
Number Reported as Trace	2
Range	0.001–0.003
BHC	
Average	0.0003
Positive Composites	
Total Number	9
Number Reported as Trace	3
Range	0.0008–0.0020
DIAZINON	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.002
MERCURY	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
LEAD	
Average	0.03
Positive Composites	
Total Number	9
Number Reported as Trace	0
Range	0.06–0.2
PCP	
Average	0.004
Positive Composites	
Total Number	7
Number Reported as Trace	0
Range	0.010–0.03
MALATHION	
Average	0.002
Positive Composites	
Total Number	3
Number Reported as Trace	0
Range	0.003–0.04
SELENIUM	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	3
Range	T
ORTHOPHENYLPHENOL	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
PCB	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
XII. Beverages	
ZINC	
Average	0.6
Positive Composites	
Total Number	30
Number Reported as Trace	0
Range	0.3–1.3
LEAD	
Average	0.01
Positive Composites	
Total Number	5
Number Reported as Trace	0
Range	0.03–0.1

(Continued next page)

TABLE 3 (cont'd.). *Levels of chemical residues found—by food class in 30 composites, August 1973—July 1974*

	Residues, ppm		
	XII. Beverages		
CADMIUM		SELENIUM	
Average	T	Average	T
Positive Composites		Positive Composites	
Total Number	6	Total Number	2
Number Reported as Trace	0	Number Reported as Trace	2
Range	0.01–0.03	Range	T

NOTE: T = trace: see Table 1, footnote 1.

TABLE 4. *Recovery data on residues found in total diet samples, August 1973—July 1974*

Residue	Type of Food Composites	Spike Level, ppm	Range of Blank Level, ppm [1]	Range of Total Found, ppm [1]	No. of Recovery Studies
Cadmium	Fatty	0.10	0-0.042 (0.116)	0.075-0.160 (0.111)	30
	Nonfatty	0.10	0-0.139 (0.023)	0.031-0.236 (0.119)	60
Lead	Fatty	0.20	0-0.088 (0.035)	0.122-0.316 (0.219)	30
	Nonfatty	0.20	0-0.896 (0.200)	0.022-1.512 (0.287)	60
Selenium	Fatty	0.20	0-0.28 (0.0887)	0.10 -0.50 (0.243)	30
	Nonfatty	0.20	0-0.40 (0.040)	0.13 -0.58 (0.212)	60
Zinc	Fatty	5.0	3.78-10.72 (5.75)	8.22 -12.84 (10.6)	19
	Nonfatty	5.0	0.35-12.7 (3.67)	4.94 -16.5 (8.62)	60
	Fatty	25.0	24.0-35.5 (29.4)	45.1 -63.6 (52.9)	11
Mercury	Fatty	0.06	0-0.030 (0.007)	0.039-0.105 (0.067)	24
	Nonfatty	0.06	0-0.008 (0.003)	0.048-0.078 (0.062)	44
	Fatty	0.03	0-0.001 T	0.027-0.033 (0.030)	6
	Nonfatty	0.03	0-0.003 (0.001)	0.028-0.041 (0.035)	16
Carbaryl	Nonfatty	0.2 0	0-0.20 (0.18)	60	
Orthophenylphenol	Nonfatty	0.4	0	0-0.40 (0.29)	59
MCP	Fatty	0.02	0	0-0.019 (0.007)	7
	Nonfatty	0.02	0	0-0.023 (0.012)	14
2, 4-DB	Fatty	0.02	0	0-0.026 (0.012)	6
	Nonfatty	0.02	0	0.004-0.032 (0.017)	12
2, 4-D	Fatty	0.02	0	0-0.017 (0.011)	6
	Nonfatty	0.02	0	0-0.020 (0.016)	14
2,4,5-TP	Fatty	0.02	0	0.004-0.025 (0.013)	6
	Nonfatty	0.02	0	0-0.025 (0.015)	12
Methyl Parathion	Fatty	0.005	0	0-0.0034 (0.0025)	5
	Nonfatty	0.005	0-0.015 (0.0002)	0-0.0050 (0.0033)	10
CIPC	Fatty	0.05	0	0.027-0.046 (0.035)	5
	Nonfatty	0.05	0	0.033-0.059 (0.047)	10

(Continued next page)

TABLE 4 (cont'd.). *Recovery data on residues found in total diet samples, August 1973—July 1974*

Residue	Type of Food Composites	Spike Level, ppm	Range of Blank Level, ppm [1]	Range of Total Found, ppm [1]	No. of Recovery Studies
Dacthal	Fatty	0.005	0	0.0023-0.0050 (0.0036)	5
	Nonfatty	0.005	0	0.0033-0.0064 (0.0050)	10
Phosalone	Fatty	0.05	0	0.022-0.053 (0.038)	5
	Nonfatty	0.05	0-0.1706 (0.017)	0.030-0.212 (0.067)	10
PCNB	Fatty	0.003	0-0.0041 (0.0009)	0.0018-0.0056 (0.0028)	5
	Nonfatty	0.003	0	0.0022-0.0034 (0.0028)	9

[1] Numbers in parentheses represent average residue levels.

TABLE 5. *Pesticide residues in individual commodities of dairy composite of four market basket samples, August 1973—July 1974* [1]

Residue Found	Commodity [2]							
	Whole Fluid Milk (4)	Evaporated Milk (4)	Ice Cream (4)	Cottage Cheese (4)	Processed Cheese (4)	Natural Cheese (4)	Butter (4)	Ice Milk (3)
	Residues, ppm							
BHC								
Times Found	3	3	3	2	4	4	4	
ppm Range	T	T-0.002	T-0.001	T-0.002	0.003-0.008	0.004-0.016	0.009-0.021	
DDE								
Times Found	4	2	3	3	4	4	4	1
ppm Range	T-0.003	T	T-0.010	T-0.002	T-0.045	T-0.050	0.006-0.042	0.002
DIELDRIN								
Times Found	2	3	4	2	3	4	4	
ppm Range	T-0.002	0.002-0.003	T-0.004	T	0.003-0.018	0.005-0.009	0.016-0.050	
HEPTACHLOR EPOXIDE								
Times Found		2	2	1	3	4	3	
ppm Range		T	T-0.001	T	T-0.003	T-0.008	0-003-0.011	
TDE								
Times Found			1		1		2	
ppm Range			T		0.005		T	
DDT								
Times Found		1			2	3	2	
ppm Range		T			0.005-0.007	T-0.012	T-0.009	
METHOXYCHLOR								
Times Found			1	2	2	1	1	
ppm Range			0.027	T-0.015	0.005-0.038	0.076	0.154	
PCB								
Times Found	1							
ppm Range	T							
LINDANE								
Times Found	1				1		1	
ppm Range	0.001				0.003		0.002	

[1] Buttermilk, skim milk, and nonfat dry milk not shown because no residues were found.
[2] Numbers in parentheses are numbers of replicates.

TABLE 6. *Pesticide residues in individual commodities of meat composite of four market basket samples, August 1973—July 1974*[1]

Residue Found	Commodity[2]														
	Roast Beef (4)	Ground Beef (4)	Pork Chops (4)	Bacon (4)	Chicken (4)	Fish Fillet (4)	Tuna or Salmon (4)	Lunch Meat (4)	Frank-furters (4)	Beef Liver (4)	Eggs (4)	Ham (4)	Round Steak (4)	Veal (4)	Lamb (1)
	Residues, ppm														
DIELDRIN															
Times Found	3	3	1	2	4	1	2	3	4	1					
ppm Range	0.005-0.52	T-0.004	0.002	0.003-0.004	0.004-0.007	0.004	T-0.001	0.002-0.006	0.002-0.009	T					
DDE															
Times Found	2	2	2	3	4	2	2	3	4	2	2	3	2	1	1
ppm Range	T-0.024	0.004-0.006	0.002-0.009	0.004-0.013	0.008-0.017	0.012-0.044	0.003-0.012	0.005-0.035	0.004-0.019	T-0.016	T-0.012	T-0.016	0.004-0.008	0.002	0.023
TDE															
Times Found	1		1	2	1		2	1	1						
ppm Range	T		0.006	0.004	0.004		0.008-010	0.008	0.003						
DDT															
Times Found		1	1	3	1	2		3	4		2	2			
ppm Range		T	0.010	0.008-0.013	0.005	0.021-0.045		0.006-0.029	0.008-0.018		T-0.016	0.011-0.016			
HCB															
Times Found						1									1
ppm Range						0.001									0.016
PCB															
Times Found		1				1									
ppm Range		T				T									
BHC															
Times Found	2	2	1	1			1	3	2			1			
ppm Range	T-0.002	T-0.005	0.001	0.001			0.010	0.001-0.002	0.002-0.003			0.001			
LINDANE															
Times Found		1	1	1				3	3						
ppm Range		0.002	0.001	0.002				0.001-0.009	0.002-0.004						
HEPTACHLOR EPOXIDE															
Times Found	1	1		1	1				2					1	1
ppm Range	0.002	0.005		0.001	T				0.002-0.004					0.002	0.006
METHOXYCHLOR															
Times Found														1	
ppm Range														0.026	
ETHION															
Times Found									1						
ppm Range									0.008						
RONNEL															
Times Found				1											
ppm Range				0.010											

[1] Shrimp not shown because no residues found.
[2] Numbers in parentheses are number of replicates.

RESIDUES IN FISH, WILDLIFE, AND ESTUARIES

Organochlorine Pesticide and Polychlorinated Biphenyl Residues in Selected Fauna from a New Jersey Salt Marsh—1967 vs. 1973[1]

Erwin E. Klaas[2] and Andre A. Belisle[1]

ABSTRACT

More than a half million pounds of DDT were applied to control mosquitoes in salt marsh estuaries of Cape May County, New Jersey, from 1946 to 1966. The use of DDT was discontinued in the County after 1966. In 1967, mean concentrations of DDT and metabolites ranged from 0.63 to 9.05 ppm in aquatic fauna, but by 1973 mean residue levels had decreased 84 to 99 percent among nine species. DDE was still present at reduced levels in nearly all samples in 1973, but other DDT isomers had mostly disappeared. Dieldrin was detected only in clapper rails, and residue levels decreased during the period. Mean concentrations of PCB's increased in the clapper rail, remained the same in the fiddler crab and mud snail, and decreased in the sheepshead minnow, mummichog, striped killifish, and salt marsh snail. Small amounts of mirex, toxaphene, cis-*chlordane (and/or* trans-*nonachlor), oxychlordane, and HCB were detected in a few specimens.*

Introduction

A narrow band of salt marshes with numerous estuaries and well-defined drainage systems extends along the eastern and southern coast of New Jersey. These marshes are important nursery areas for estuarine fauna, but because of their location near the large metropolitan areas of New York City, Philadelphia, and Baltimore, they are affected by real estate development and environmental pollution.

Cape May County, just southwest of Atlantic City, has over 50,000 acres of salt marsh bordering the Atlantic Ocean and Delaware Bay. This seashore County has been a popular summer resort for a century or more. After World War II, more people than ever before were attracted to the area and State and local governments tried to reduce the mosquito population to provide a more habitable environment for residents and vacationers, and to control the spread of mosquito-borne diseases.

DDT was first used in Cape May County in 1946 and was used for mosquito control until 1966, when it was replaced by organophosphates, chiefly malathion, fenthion (Baytex), and more recently, Abate.

In September 1967, Hurricane Doria hit the coast of New Jersey, causing high storm tides and killing clapper rails. Several hundred birds were found dead along causeways in Cape May County, and an estimated 2,000 or more died in the marshes. Biologists at the Patuxent Wildlife Research Center, U.S. Department of Interior—Fish and Wildlife Service, obtained 43 dead rails from six localities (Fig. 1). Concurrently, fish and invertebrates were collected from these locations and were frozen and stored. Sampling was repeated at the same localities in 1973. The two groups of samples collected 7 years apart, the first having been a year after use of DDT was discontinued in Cape May County, were then analyzed by the same procedures.

This paper reports residue levels of organochlorine pesticides and polychlorinated biphenyls (PCB's) detected in these samples and compares findings of 1967 and 1973. The history of pesticide spraying for mosquito control in Cape May County is reviewed as it pertains to residue levels.

History of Pesticide Use for Mosquito Control

The history of pesticide use on mosquitoes in Cape May County was obtained from the Proceedings of Annual Meetings of the New Jersey State Mosquito Extermination Association (*9, 13-15, 17, 18, 21*) and from unpublished daily work records in the files of the Cape May County Extermination Commission.

[1] Patuxent Wildlife Research Center, Fish and Wildlife Service, U.S. Department of Interior, Laurel, Md. 20811.

[2] Iowa Cooperative Wildlife Research Unit, Iowa State University, Ames, Iowa.

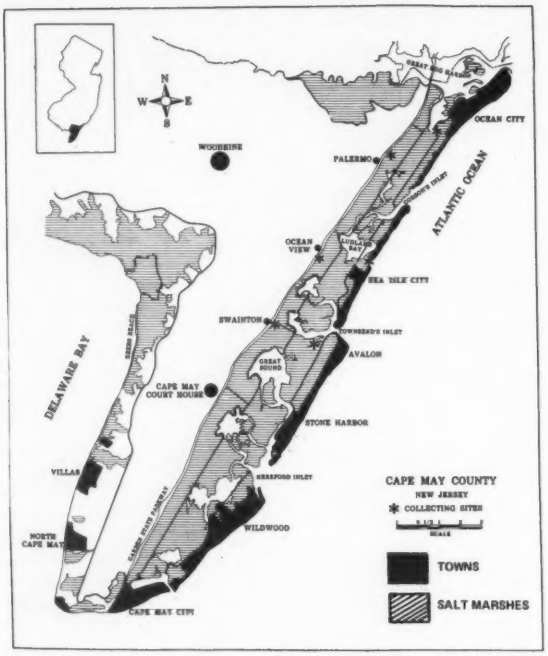

FIGURE 1. *Aerial spray zones and fauna collection sites in salt marshes of Cape May County, New Jersey*

Ditching, draining, and other methods of water control were the principal means of limiting mosquitoes in Cape May County before 1946. Small quantities of fuel oil and pyrethrum were applied as larvacides. In 1946, the County acquired an aerosol fog unit for control of adult mosquitoes. This machine was used to apply a 5 percent DDT emulsion in fuel oil along the streets of resort communities bordering the Atlantic Ocean in the summer of 1946 (*18*). The amounts of pesticide used in 1946-47 are unknown. In 1948 the mosquito control program included fog, mist, and spray work with DDT, TDE, and pyrethrum; total quantity used was 19,450 gallons. The marshes just west of Sea Isle City received an experimental aerial application June 15, 1948 (*21*).

By 1949, DDT was the principal chemical used for mosquito control in New Jersey (*9*). It was usually applied as a 5 percent emulsion in oil or as a wettable powder. For adult mosquito control, DDT was applied at 0.1 lb/acre; as a larvacide it was applied in early spring at 1-2 lb/acre in restricted areas. Statewide, oil was second in importance to DDT, and pyrethrum larvacide was third. The amount of DDT used in Cape May County in 1949 had risen to 25,465 gallons of emulsion applied from the ground, 1,050 gallons from the air, and 6,000 pounds of DDT dust applied from the ground (*17*). Neither oil nor pyrethrum was used extensively after 1946.

Aerial spraying, supported by State funds, was begun on a wide scale in 1949. Areas to be sprayed included a band 2,000 feet wide which began at Cape May Point and continued west of the Atlantic seashore resort towns up to and including Ocean City. A similar band extended just east of the Garden State Parkway. Another band extended along the shore of Delaware Bay (Fig. 1). These bands were divided into 29 zones of known acreage to facilitate aerial application. A wide perimeter around the inland town of Woodbine was sprayed regularly from the air.

Aerial sprays were applied from heights of 50-75 feet at a rate of 0.1 lb of technical DDT in 1 quart of petroleum solvent per acre of ground surface (*13-15*). These formulation and application rates for aerial and most ground spraying of DDT were continued through 1966. DDT emulsion was sometimes applied as a larvacide in restricted areas at rates of 0.3 lb/acre (*13*). About half of all DDT applied between 1950 and 1966 was sprayed from the air; the remainder was dispersed from the ground through aerosol fog machines, truck- and tractor-mounted tank sprayers, and hand sprayers.

The total amount of active DDT applied in Cape May County from 1949 to 1966, assuming the formulation rate (0.4 lb/gal) remained the same for all years, was estimated to be 614,970 lb. Yearly amounts increased steadily from 1,926 lb in 1949 to a high of 58,515 lb in 1963 (Table 1). Malathion and fenthion began to replace DDT in 1964 and by 1966 DDT use had declined to 33,186 lb.

About 8-10 percent of all DDT applied after 1955 was in dust or pellet forms. Pellets contained either 5 or 10 percent active DDT and were usually applied at rates of 10 or 20 lb/acre (1.0 lb DDT). In the early 1960's pellets were used extensively as a larvacide.

After 1966, malathion became the principal chemical for mosquito control in Cape May County, although small amounts had been used earlier. Fenthion was also used in pellet form in some areas. Use of malathion and fenthion was essentially discontinued about 1971. Abate was first used in 1969, and by 1973 it was the only chemical in widespread use for mosquito control.

Table 2 summarizes the amount of DDT applied 1950-66 as emulsion to each of the six zones from which biotic samples were collected (Fig. 1). These zones, named after the largest nearby town, are Ocean City, Sea Isle City, Avalon, Palermo, Ocean View, and Swainton; they correspond to 6 of the 21 aerial spray zones designated on daily work records and maps of the County Mosquito Extermination Commission. The remaining 15 zones have been grouped into Atlantic Shore and Bay Shore areas for the purpose of this summary. The Atlantic Shore area includes five aerial spray zones along the Atlantic shore from Swainton and Stone Harbor to Cape May and one

TABLE 1. *Active DDT applied each year as emulsion, pellets, or dust in Cape May County, New Jersey, by County Mosquito Extermination Commission—1949-66*[1]

YEAR	POUNDS	YEAR	POUNDS
1949	1,926	1959	43,897
1950	8,861	1960	53,668
1951	18,189	1961	51,206
1952	19,587	1962	45,920
1953	22,853	1963	58,515
1954	26,117	1964	56,634
1955	24,267	1965	45,941
1956	29,018	1966	33,186
1957	37,531		
1958	37,654	TOTAL	614,970

[1] Total area sprayed was 46,638 acres.

TABLE 2. *Active DDT applied as emulsion in different areas of Cape May County, New Jersey—1950-66*

Zone	Acres	Pounds	Pounds/Acre
Ocean City	3,000	57,103	19.0
Sea Isle City	1,500	34,486	23.0
Avalon	2,900	43,582	15.0
Palermo	2,100	14,510	6.9
Ocean View	1,180	7,961	6.8
Swainton	960	4,854	5.1
Atlantic Shore	13,631	192,676	14.1
Bay Shore	21,367	208,975	9.8
Total	46,638	564,147	12.1

zone northwest of Palermo. The Bay Shore area includes nine aerial spray zones on the Delaware Bay shore, Woodbine, and most of the rural areas, roads, and municipalities west of the Garden State Parkway. The Atlantic Shore and Bay Shore areas are included in this summary to complete the spraying data for the entire County. It is possible that residues were transported to the six sampling zones from the Atlantic Shore or Bay Shore areas by wind drift, tidal action, and water shed runoff.

Daily work records of aerial and ground applications included the spray site and the amount of emulsion dispersed at each location. Generally, each spraying location itemized on the work sheets could be assigned to one of the eight zones listed in Table 2 and shown in Figure 1. Quantity of DDT applied in pellet form is not included in Table 2 because exact locations where pellets were used could not always be determined.

Because most DDT used in both aerial and ground operations was dispersed in zones of known acreage, rough estimates of the total lb/acre applied in each zone in the 17-year period could be made (Table 2). The rates varied from 5.1 lb/acre in the Swainton zone to 23.0 lb/acre at Sea Isle City with a mean of 12.1 for all zones. Spraying was generally heavier in zones nearest the ocean. Annually, the rate of application for the entire County averaged 0.7 lb/acre and ranged from 0.2 lb/acre in 1950 to 1.1 lb/acre in 1963.

This brief history of pesticide use in Cape May County does not include pesticides applied on private lawns or gardens, agriculture lands, golf courses, or military bases. Truck crops are the chief agricultural products and most of the cropland is in the western part of the County. More extensive areas of cropland are found in counties to the west and north, and chemicals applied there may have eventually entered estuaries in Cape May County through runoff. Military bases cooperated with the County's mosquito program by furnishing some chemicals to be sprayed on military land, but it is not known how extensively these authorities may have sprayed on their own. Some larger communities along the Atlantic shore owned aerosol fog machines and applied limited amounts of chemicals. Undoubtedly, the County Mosquito Extermination Commission was the largest user of pesticides in Cape May County and dispersed the bulk of organochlorines entering the local environment during 1946-66.

Sample Collection and Preparation

Biotic samples were obtained at six of the spraying zones in Cape May County marshes in 1967 and 1973 (Fig. 1) during September 19-23. Collecting points were Ocean City: north side of New Jersey State Highway 23, and 0.5 mile west of State Highway 56; Sea Isle City: west of Highway 19 at the end of 30th Street; Avalon: south side of Highway 1, and 1 mile west of Highway 30; Palermo: east side of Garden State Parkway, 2 miles south of Highway 23; Ocean View: south side of Highway 25, 0.2 mile east of Garden State Parkway; Swainton: south side of Highway 1, 0.5 mile east of Garden State Parkway. Scientific and vernacular names of animal species in the study are listed in Table 3. Scientific and vernacular names of plants appear in the text.

Cape May County marshes are typical cordgrass (*Spartina alterniflora*) salt marshes. The taller (4-6 ft) dense saltmarsh cordgrass occurred as a narrow band along tidal creeks; the shorter (< 1 ft) sparse cordgrass covered the remainder of the marsh. The height of vegetation appeared to be correlated with the degree of tidal inundation; short grass was subject to less frequent inundation than was tall grass.

Marshes averaged about 3 miles wide in the area where samples were collected and were divided into an inland side and an ocean side by a meandering channel, the intercoastal waterway. Ocean City, Sea Isle City, and Avalon are on the ocean side of the marsh; Palermo, Ocean View, and Swainton are on the inland side.

In 1967, 40 dead clapper rails were picked up along highway causeways after the hurricane September 17. One rail was shot at the Palermo site September 2, one was found dead at Palermo August 15 immediately following an aerial application of malathion, and one was shot at the Sea Isle City site September 2. In 1973, all

TABLE 3. *Organisms analyzed for organochlorine residues in Cape May County, New Jersey—1967 vs. 1973*

Common and Scientific Names	
Clapper Rail	*Rallus longirostris*
Sheepshead Minnow	*Cyprinidon variegatus*
Mummichog	*Fundulus heteroclitus*
Striped Killifish	*Fundulus majalis*
Grass Shrimp	*Palaemonetes* sp.
Fiddler Crab	*Uca pugnax*
Blue Crab	*Callinectes sapidus*
Ribbed Mussel	Geukensia demissa
Periwinkle	*Littorina littorea*
Mud Snail	*Ilyanassa obsoleta*
Salt Marsh Snail	*Melampus bidentatus*
Meadow Grasshopper	*Conocephalus fasciatus*

rails were shot. Carcasses were wrapped in aluminum foil, placed in plastic bags, and frozen until analysis.

Fish were seined from shallow pools and tidal creeks. Fiddler crabs and mussels were dug from their burrows and snails were picked from the mud or vegetation by hand. Samples were placed in acetone-rinsed glass bottles at the time of collection, and were frozen.

Before extraction and chemical analysis, clapper rails were skinned; as much subcutaneous fat as possible was retained with the carcass. Beaks, legs, and digestive tracts were removed and carcasses were homogenized. Stomachs were held for later identification of contents.

Fish and invertebrate samples were rinsed in distilled water to remove external soil and debris, and were drained briefly before homogenization. Total individuals of each species were pooled into a single sample for each sampling point. Fish and fiddler crabs were homogenized whole. Shells of periwinkles, mud snails, and ribbed mussels were removed and discarded. Only the salt marsh snail was homogenized with its shell because the animal is so small.

Because the samples of 1967 had been stored frozen for several years, authors compared moisture content with that of 1973 samples. Small aliquots of each invertebrate species from 1967 and 1973 were oven-dried at 100°C until weights remained constant for 2 days. No significant differences in moisture content between years were detected; hence residues expressed on a wet-weight basis are considered comparable for both groups.

Chemical Analysis

The biotic material was ground and a suitable aliquot, usually 10 g, was mixed with sodium sulphate to remove moisture. This mixture was transferred to a paper thimble and extracted with hexane for about 7 hours. Paper thimbles were pre-extracted for 7 hours in methylene chloride to remove background peaks. Cleanup was accomplished by column chromatography; the concentrated extract was placed on a florisil column and eluted with 200 ml 6 percent ethyl ether in hexane. The florisil eluate was concentrated and eluted from a silicic acid column to separate pesticides from PCB's. These procedures are described in detail by Cromartie et al. (*4*).

Samples were analyzed with an electron-capture gas chromatograph equipped with a 4 percent/6 percent SE-30/QF-1 column as 190°C. Pesticides were quantitated with a computing integrator; PCB's were estimated by comparing total area with Aroclor 1248 or 1254. Residues in about 10 percent of the samples were confirmed on a gas chromatograph/mass spectrometer.

Average percentage recoveries from spiked mallard carcass tissue were: DDE, 96; TDE, 103; DDT, 112; dieldrin, 101; heptachlor epoxide, 104; oxychlordane, 98; *cis*-chlordane, 100; *cis*-nonachlor, 98; HCB, 69; and Aroclor 1254, 101. Residue data were not corrected for percentage recoveries.

Limits of sensitivity were 0.01 ppm for pesticides and 0.02 ppm for PCB's in fish and invertebrate samples; corresponding limits in clapper rail samples were 0.1 ppm for pesticides and 0.5 ppm for PCB's.

For statistical analysis, residue values were converted to logarithms base 10 after adding 1.0 to all values to allow the use of zero values. Geometric means are the antilogs of log means minus one. For PCB residues that could only be quantified as <0.5 ppm, an arbitrary value of 0.25 ppm was assumed in calculating means.

Results and Discussion

One-hundred-fifty-nine samples representing 12 species of vertebrates and invertebrates were analyzed for organochlorines and PCB's (Tables 4-6). The most frequently found chemical among all the samples was *p,p*-DDE; it occurred in 97 percent of the samples. Four other isomers of DDT also were found but their occurrence varied with the year of collection and the species of organism. For instance, *p,p'*-DDT was detected in 86 percent of the fish and invertebrate samples in 1967 but in only 6 percent in 1973. In clapper rails, the incidence of this chemical decreased from 37 percent in 1967 to 0 percent in 1973.

The isomer *p,p'*-TDE occurred in all fish samples from both 1967 and 1973, but among the invertebrates, its incidence decreased from 82 percent in 1967 to 42 percent in 1973. Among clapper rail samples the incidence decreased even more dramatically: from 63 percent to 4 percent. The lower incidence of *p,p'*-TDE and *p,p'*-DDT in rails was not unexpected because birds evidently metabolize *p,p'*-DDT readily into *p,p'*-DDE and *p,p'*-TDE, and there is a greater propensity for storage of DDE than TDE in bird tissue (*1,2*). Also, the rail samples

were analyzed as individuals whereas fish and invertebrates were analyzed as pooled samples in which each sample contained five or more individuals.

The isomers *o,p'*-DDT and *o,p'*-TDE were found in 71 percent of the invertebrate samples of mussels, mud snails, and salt marsh snails in 1967, but were not found in any samples in 1973. These isomers are not often detected in wildlife specimens although technical grade DDT contains up to 30 percent *o,p'*-DDT (*19, 26*). Lamont (*19*) found *o,p'* isomers in brown pelican (*Pelicanus occidentalis*) eggs collected in California in 1969, and in tissues of mallard ducks (*Anas platyrhynchos*) that had been fed *o,p'*-DDT for 10 weeks. An average ratio of 0.2 between *p,p'*-DDT and *o,p'*-DDT was reported for Lake Michigan fish in 1971 (*26*). However, *o,p'*-DDT was not detected in fish samples from New Jersey in 1967 or 1973.

Species differences in incidence of the various DDT isomers is probably the result of selective degradation in food and tissues caused by differences in metabolic pathways, storage, half-lives, and excretion rates in the various organisms (*16, 20*).

Changes in relative occurrence of DDE analogs between 1967 and 1973 were accompanied by changes in relative magnitude of residue levels in those years. Changes in magnitude and occurrence are obvious in Tables 4-6. Changes in magnitude of ΣDDT (Table 7) were tested by Wilcoxen's two-sample nonparametric test (*24*) for 9 of the 12 species sampled. Residue levels in all 9 species were significantly lower in 1973 ($p<0.05$). Decreases in ΣDDT varied from 84 to 99 percent of 1967 levels.

Mean residues of ΣDDT observed in 1967 ranged from 0.63 ppm in the periwinkle to 9.05 ppm in the mummichog. Each of the three species of fish contained higher mean residue levels than did any other species sampled.

Residues of ΣDDT averaged 3.36 ppm in clapper rails in 1967. Clapper rails feed principally on fiddler crabs in which DDT averaged 1.33 ppm in 1967. In 1973, DDT residues had dropped to 0.54 ppm in rails and 0.13 ppm in fiddler crabs. No significant differences ($p<0.05$) in residues were detected between male and female rails or between adults and immatures. In an acute toxicity study by Van Velzen and Kreitzer (*25*) clapper rails were highly tolerant of DDT, and the authors concluded that exposure to this pesticide in marshes probably does not cause death among adult rails. Ferrigno (*7*) observed production crashes in clapper rail populations in Cape May County in 1959 and 1965. Hatching success remained low from 1965 to 1969 but began to increase in 1970 (F. Ferrigno, Sr., State of New Jersey Department of Environmental Protection, 1973; personal communication). Peak years in hatching success were 1958, 1962, and 1972. Population studies were not conducted before the DDT era, so it would be interesting to document long-term rail population trends to see whether similar production crashes occur after the DDT era.

Mean and maximum residues of DDT in fish (Table 5)

TABLE 4. *Chlorinated hydrocarbon residues in carcasses of the clapper rail* (Rallus longirostris) *from six localities in Cape May County, New Jersey—1967 and 1973*

	Residues, ppm wet weight			
	1967		1973	
	Mean[1]	Range	Mean[1]	Range
Ocean City				
p,p'-DDE	1.8	0.55-5.3	0.49	0.20-1.2
p,p'-TDE	0.10	ND-0.28	ND	—
p,p'-DDT	ND	—	ND	—
Dieldrin	0.14	ND-0.23	0.04	ND-0.19
PCB's	<0.5	—	0.44	<0.5-1.1
Carcass wt, g	130.3	67.2-185.0	219.4	177.5-255.0
Percent lipid	4.1	2.4-7.1	8.1	2.1-17.1
No. samples	7		4	
Sea Isle City				
p,p'-DDE	2.7	1.1-7.0	0.60	0.31-0.77
p,p'-TDE	0.25	ND-1.9	ND	—
p,p'-DDT	0.14	ND-1.1	ND	—
Dieldrin	ND	—	ND	—
PCB's	<0.5	—	0.70	<0.5-2.0
Carcass wt, g	148.2	120.0-170.3	203.0	182.0-256.5
Percent lipid	3.5	1.9-6.5	8.7	5.1-12.9
No. samples	8		4	
Avalon				
p,p'-DDE	3.0	2.1-4.0	0.89	0.33-3.4
p,p'-TDE	0.10	ND-0.25	ND	—
p,p'-DDT	0.04	ND-0.17	ND	—
Dieldrin	0.04	ND-0.18	0.02	ND-0.11
PCB's	<0.5	—	0.83	<0.5-3.4
Carcass wt, g	127.6	94.3-149.0	206.7	164.0-254.0
Percent lipid	5.0	3.9-8.1	11.7	4.9-16.0
No. samples	7		6	
Palermo				
p,p'-DDE	6.3	2.5-15	0.78	0.33-1.9
p,p'-TDE	0.88	ND-2.3	ND	—
p,p'-DDT	0.81	ND-3.0	ND	—
Dieldrin	0.08	ND-0.22	0.02	ND-0.10
PCB's	<0.5	—	1.3	0.73-2.5
Carcass wt, g	144.4	77.4-214.2	202.8	177.5-243.5
Percent lipid	5.1	2.6-9.3	14.6	9.5-20.9
No. samples	7		6	
Ocean View				
p,p'-DDE	3.4	1.4-11.0	0.20	0.18-0.21
p,p'-TDE	0.26	ND-0.90	ND	—
p,p'-DDT	0.23	ND-0.48	ND	—
Dieldrin	0.08	ND-0.18	ND	—
PCB's	<0.5	—	0.55	<0.5-0.93
Carcass wt, g	151.8	74.9-184.3	181.5	167.0-196.0
Percent lipid	4.0	2.0-8.1	5.6	5.6-5.7
No. samples	7		2	
Swainton				
p,p'-DDE	3.4	0.78-8.8	0.54	0.31-1.6
p,p'-TDE	0.18	ND-0.68	0.03	ND-0.17
p,p'-DDT	0.15	ND-1.6	ND	—
Dieldrin	0.03	ND-0.11	ND	—
PCB's	<0.5	—	0.14	ND-0.5
Carcass wt, g	153.1	90.0-186.7	174.1	65.0-263.0
Percent lipid	5.0	2.5-7.1	8.2	2.8-14.2
No. samples	7		5	

Note: Three samples from 1973 contained mirex: Ocean City, 0.16 ppm; Sea Isle City, 0.39 ppm; Avalon, 0.15 ppm. The same sample from Avalon also contained 0.12 ppm oxychlordane.

ND = not detected.

[1] Mean values for chemical residues are geometric means; mean values for carcass weight and percent lipid are arithmetic means.

TABLE 5. *Chlorinated hydrocarbon residues in pooled samples of fish from Cape May County, New Jersey—1967 and 1973*

Locality	Year	n[1]	Sample weight, g	Percent lipid	Residues, ppm wet weight			
					p,p'-DDE	*p,p'*-TDE	*p,p'*-DDT	PCB's
Sheepshead minnows (*Cyprinidon variegatus*)								
Ocean City	1967	56	23.8	3.8	1.5	4.0	2.0	0.60
	1973	168	200.3	4.3	0.12	0.55	ND	0.16
Sea Isle City	1967	88	86.0	4.8	1.7	15	4.2	1.1
	1973	121	160.8	5.4	0.38	0.53	ND	0.13
Avalon	1967	41	42.4	5.7	0.44	2.8	1.2	0.91
	1973	273	279.06	4.0	0.06	0.06	ND	0.18
Palermo	1967	46	30.9	4.2	3.5	12	5.5	1.5
Ocean View	1967	40	34.1	4.8	0.45	2.2	0.55	4.3
	1973	103	129.82	4.1	0.07	0.06	ND	0.18
Swainton	1973	88	100.56	4.3	0.10	0.18	ND	0.14
Striped killifish (*Fundulus majalis*)								
Ocean City	1973	28	29.9	2.2	0.14	0.52	ND	0.17
Sea Isle City	1967	3	3.6	3.9	2.3	9.2	9.5	2.8
	1973	8	9.4	2.8	0.15	0.15	ND	0.22
Avalon	1973	28	31.9	2.5	0.05	0.04	ND	0.17
Palermo	1973	30	35.0	3.0	0.19	0.07	ND	0.19
Ocean View	1967	19	31.3	2.0	0.55	1.8	0.55	2.3
	1973	17	18.3	3.1	0.06	0.04	ND	0.14
Swainton	1967	40	75.4	2.1	0.40	0.55	0.08	0.41
	1973	14	10.5	2.2	0.06	0.04	ND	0.20
Mummichogs (*Fundulus heteroclitus*)								
Ocean City	1967	20	6.9	4.2	2.0	3.6	4.8	0.83
	1973	73	73.2	2.2	0.10	0.33	ND	0.12
Sea Isle City	1967	30	38.0	4.6	10	9.9		
	1973[2]	3	18.5	3.5	0.22	0.09	12	0.02
				2.7				
				0.29				
Avalon	1967	40	80.2	4.9	1.3	3.2	1.6	1.5
	1973	21	48.7	2.6	0.06	0.05	ND	0.23
Palermo	1967	60	46.3	3.4	10	11	13	2.0
	1973	40	45.6	2.9	0.21	0.08	ND	0.18
Ocean View	1967	18	79.2	3.8	2.3	5.5	1.7	1.3
	1973	21	29.6	2.3	0.08	0.03	ND	0.19
Swainton	1967	64	88.9	3.2	0.45	0.39	ND	3.5
	1973[3]	22	15.71	3.0	0.09	0.04	ND	0.23
Mummichogs (*Fundulus heteroclitus*)								
Ocean City	1967	20	6.9	4.2	2.0	3.6	4.8	0.83
	1973	73	73.2	2.2	0.10	0.33	ND	0.12
Sea Isle City	1967	30	38.0	4.6	10	9.9	12	2.7
	1973[2]	3	18.5	3.5	0.22	0.09	0.02	0.29
Avalon	1967	40	80.2	4.9	1.3	3.2	1.6	1.5
	1973	21	48.7	2.6	0.06	0.05	ND	0.23
Palermo	1967	60	46.3	3.4	10	11	13	2.0
	1973	40	45.6	2.9	0.21	0.08	ND	0.18
Ocean View	1967	18	79.2	3.8	2.3	5.5	1.7	1.3
	1973	21	29.6	2.3	0.08	0.03	ND	0.19
Swainton	1967	64	88.9	3.2	0.45	0.39	ND	3.5
	1973[3]	22	15.71	3.0	0.09	0.04	ND	0.23

NOTE: ND = not detected.
[1]n = number of individual fish in the pooled sample.
[2]0.02 ppm *cis*-chlordane or *trans*-nonachlor detected in sample.
[3]0.01 ppm *cis*-chlordane or *trans*-nonachlor detected in sample.

collected in 1967 are high compared with residues reported in an extensive summary by Edwards (*6*) for marine and freshwater fish. A pooled sample of the sheepshead minnow and another of mummichog from Long Island in 1966 contained 0.94 ppm and 1.24 ppm ΣDDT, respectively (*27*). Veith reported mean DDT residues in 13 species of fish from Lake Michigan that ranged from 0.9 to 7.1 ppm (*26*). Fish from the Delaware River in New Jersey, analyzed as part of the National Pesticide Monitoring Program, had some of the highest mean residues of ΣDDT recorded on the Atlantic Coast; average levels reached 45 ppm in 1968 (*10, 11*).

It is likely that New Jersey fish developed increased tolerance to DDT and its analogs after 20 years of continued DDT use in their habitat. Residues in 1967 samples, however, were much lower than those observed in genetically resistant mosquitofish (*Gambusia affinis*) in Texas which had average ΣDDT residues greater than 50 ppm on a whole-body basis (*5*).

Odum et al. (*22*) found that fiddler crabs that had fed on detritus containing approximately 10 ppm DDT residues developed poor coordination after 5 days, and residues in the claw muscles of these crabs averaged 0.885 ppm after 10 days. Residues in whole bodies of crabs from New Jersey in 1967 averaged 1.33 ppm, and ranged as high as 4.13 in one sample. The crabs were alive when collected

TABLE 6. *Chlorinated hydrocarbon residues in pooled samples of invertebrates from Cape May County, New Jersey —1967 and 1973*

Locality	Year	Sample weight, g	Percent lipid	Residues, ppm wet weight					
				p,p'-DDE	*p,p'*-TDE	*o,p'*-TDE	*p,p'*-DDT	*o,p'*-DDT	PCB's
Fiddler crab (*Uca pugnax*)									
Ocean City	1973[1]	33.78	0.9	0.12	0.09	ND	ND	ND	0.13
Sea Isle City	1967[2]	17.40	0.7	3.6	0.27	ND	0.32	ND	0.09
	1973	115.93	0.9	0.11	0.04	ND	ND	ND	0.11
Avalon	1967	41.13	1.4	0.41	0.19	ND	0.10	ND	0.17
	1973	70.37	1.1	0.06	0.05	ND	0.01	ND	0.10
Palermo	1967	26.47	0.8	1.3	0.14	ND	0.04	ND	0.23
	1973	40.57	0.5	0.76	ND	ND	ND	ND	0.27
Ocean View	1967	11.75	0.8	1.9	0.19	ND	0.29	ND	0.25
	1973	105.63	0.8	0.06	ND	ND	ND	ND	0.27
Swainton	1967	46.40	1.8	0.28	0.06	ND	0.07	ND	0.11
	1973	133.15	0.6	0.03	ND	ND	ND	ND	0.16
Ribbed Mussel (*Geukensia demissa*)									
Ocean City	1967	55.75	0.8	0.27	0.36	0.07	2.3	0.47	0.17
	1973	91.36	0.4	0.02	0.01	ND	ND	ND	ND
Sea Isle City	1967	62.64	0.3	0.37	0.51	0.09	3.6	0.73	0.05
	1973	107.97	0.2	0.01	0.01	ND	ND	ND	ND
Avalon	1973	101.59	0.2	0.02	ND	ND	ND	ND	0.10
Palermo	1967	25.19	0.7	0.94	1.5	0.23	9.0	1.2	0.36
	1973	83.98	0.2	0.06	0.03	ND	0.02	ND	0.22
Ocean View	1967	54.95	0.6	0.20	0.24	0.05	1.6	0.20	0.27
	1973	56.05	0.5	0.02	ND	ND	ND	ND	0.02
Swainton	1967	66.92	0.2	0.02	ND	ND	ND	ND	0.10
	1973	37.03	0.3	0.03	ND	ND	ND	ND	0.24
Periwinkle (*Littorina littorea*)									
Ocean City	1973	2.76	1.1	ND	ND	ND	ND	ND	ND
Sea Isle City	1973	55.33	1.4	0.04	ND	ND	ND	ND	ND
Avalon	1967	1.34	1.5	0.14	0.31	ND	0.18	ND	0.72
	1973	64.89	2.6	0.02	ND	ND	ND	ND	0.14
Palermo	1973	25.47	0.9	0.02	ND	ND	ND	ND	0.15
Ocean View	1973	8.87	2.2	0.04	ND	ND	ND	ND	0.29
Swainton	1973	4.08	4.2	0.04	ND	ND	ND	ND	0.30
Mud snail (*Ilyanassa obsoleta*)									
Ocean City	1967[3]	4.69	0.2	0.30	0.77	0.13	0.47	0.07	0.07
	1973[3]	30.51	0.2	0.05	0.02	ND	ND	ND	0.06
Sea Isle City	1967	10.68	2.1	1.6	4.3	0.82	0.85	0.02	0.13
	1973	66.91	0.8	0.14	0.07	ND	ND	ND	0.06
Avalon	1967	5.51	0.4	0.05	ND	ND	ND	ND	0.12
	1973	53.20	1.3	0.03	0.03	ND	ND	ND	0.14
Palermo	1973	39.15	0.9	0.04	0.02	ND	ND	ND	0.16
Ocean View	1973	59.38	0.9	0.04	ND	ND	ND	ND	0.34
Swainton	1973	35.72	1.0	0.03	ND	ND	ND	ND	0.02
Salt marsh snail (*Melampus bidentatus*)									
Ocean City	1967	6.79	1.3	0.46	1.2	0.10	2.4	0.16	0.07
	1973	29.16	0.7	0.06	0.04	ND	ND	ND	ND
Sea Isle City	1967	17.19	1.1	1.0	2.5	0.21	2.9	0.28	0.08
	1973	43.23	0.6	0.01	0.01	ND	ND	ND	0.06
Avalon	1967	16.85	1.3	0.06	0.20	ND	0.30	ND	0.07
	1973	29.73	0.4	ND	ND	ND	ND	ND	0.06
Palermo	1967	27.25	1.8	2.0	5.0	0.45	6.0	0.41	1.4
	1973	25.89	0.8	0.02	0.02	ND	ND	ND	0.06
Ocean View	1967	12.42	1.7	0.76	1.1	0.08	3.5	0.14	0.34
	1973	37.99	0.6	0.01	ND	ND	ND	ND	0.13
Swainton	1967	28.30	1.0	0.05	0.06	ND	0.13	ND	0.06
	1973	37.71	0.4	<0.01	ND	ND	ND	ND	0.06
Grass Shrimp (*Palaemonetes* sp.)									
Ocean City	1973	39.47	1.0	0.02	0.01	ND	ND	ND	0.05
Sea Isle City	1973	180.30	0.5	0.02	ND	ND	ND	ND	ND
Avalon	1967	3.97	0.5	ND	ND	ND	ND	ND	<0.02
Swainton	1973	7.81	0.5	ND	ND	ND	ND	ND	ND
Blue crab (*Callinectes sapidus*)									
Ocean City	1973	6.95	4.8	0.03	0.09	ND	ND	ND	ND
Avalon	1967	41.28	2.9	0.87	ND	ND	ND	ND	0.11
Avalon	1973	6.50	1.0	0.02	ND	ND	ND	ND	0.28
Meadow Grasshopper (*Conocephalus fasciatus*)									
Palermo	1973[4]	6.32	4.0	ND	ND	ND	ND	ND	ND

NOTE: ND = not detected.
[1] 0.13 ppm oxychlordane present in sample.
[2] 0.04 ppm toxaphene present in sample.
[3] 0.02 ppm HCB detected in samples.
[4] 0.02 ppm *cis*-chlordane and/or *trans*-nonachlor detected in sample.

TABLE 7. *Comparison of ΣDDT residues in selected biota from salt marshes, Cape May County, New Jersey—1967 vs. 1973*

Species	Residues, ppm wet weight						Percent change[2]
	1967			1973			
	N[1]	Geometric mean	Range	N[1]	Geometric mean	Range	
Clapper Rail	43	3.36	0.55-18.70	27	0.54	0.18-3.4	−84
Sheepshead Minnow	5	8.59	3.20-21.00	5	0.31	0.12-0.91	−96
Mummichog	6	9.05	0.84-34.00	6	0.20	0.11-0.43	−98
Striped Killifish	3	3.97	1.03-21.00	6	0.19	0.09-0.66	−95
Fiddler Crab	5	1.33	0.41-4.19	6	0.13	0.03-0.76	−90
Ribbed Mussel	5	1.61	0.02-12.87	6	0.03	0.02-0.11	−98
Periwinkle	1	0.63	—	6	0.03	0.00-0.04	−95
Mud Snail	3	0.87	0.05-7.59	6	0.06	0.03-0.21	−93
Salt Marsh Snail	6	2.60	0.24-13.86	6	0.03	0.00-0.10	−99

[1] For clapper rail, n = number of individuals; for all others, n = number of pooled samples.
[2] Changes are all significant at probability levels of 0.05 or less (two-tailed, Wilcoxen two-sample test).

but behavior was not recorded. Crabs collected in 1973 behaved normally and were not sluggish or awkward when DDT residues ranged from 0.03 to 0.76 ppm.

Residue levels in the mollusks collected in 1967 were generally higher than levels reported by Edwards (*6*) for a wide variety of related species except oysters. The maximum ΣDDT residues reported in eastern oysters (*Crassostrea virginica*) collected in the New Jersey waters of Delaware Bay June 1966—June 1972 was 0.272 ppm, and most residues in these extensive samples were less than half this amount (*3*). Concentrations in the oysters decreased during the 1966-72 collection period. Woodwell et al. (*27*) reported 0.26 ppm ΣDDT in mud snails and 0.44 ppm ΣDDT in the hard clam (*Mercenaria mercenaria*) from Long Island, New York, in 1966 when DDT use was curtailed there. Concentrations of DDT and its metabolites were low in six species of shellfish collected in Long Island waters during 1968-1970; only a few values were greater than 0.22 ppm (*8*).

Although residue levels varied at the six localities in New Jersey, simple correlation coefficients between ΣDDT residues and amounts of DDT sprayed for mosquito control at these localities were low and statistically nonsignificant ($p>0.05$). However, residue levels of ΣDDT were consistently higher in all species at Palermo and Sea Isle City. The Sea Isle City zone was sprayed more than the other localities during the 17 years of recorded DDT usage (Table 2), but Palermo was sprayed less than either Ocean City or Avalon. Foehrenbach (*8*) was able to correlate pesticide concentrations in shellfish with land use in the watersheds surrounding his collecting stations. It is possible that other pesticide use in the Palermo watershed contributed to concentrations in the biota there. Another explanation is that DDT sprayed from the air drifted with prevailing offshore breezes toward Palermo from Sea Isle City and Ocean City. Because of the widespread coverage of DDT spraying in Cape May County and the short distances involved, further interpretation of observed differences in residue levels between localities is pointless.

PCB's were the second most common residue found. They occurred in 93 percent of all samples. Significant changes in concentrations occurred between 1967 and 1973 (Table 8), but the pattern was not so consistent in all species as it was for ΣDDT. Residues decreased in all three species of fish and in the salt marsh snail. A large increase in residues occurred in clapper rails but mean levels remained low. Changes in other species were not significant.

Dieldrin was not found in fish and invertebrates but did occur in 37 percent of the rail carcasses in 1967. Only 11 percent of the rails collected in 1973 contained dieldrin. Dieldrin apparently was never used for mosquito control in Cape May County but, until banned in 1974, it had been used widely in the United States as an insecticide. Clapper rails feed primarily on fiddler crabs but occasionally take small fish and snails. The absence of dieldrin in any of these species may mean that rails obtained the chemical from salt marsh organisms not included in this study, or that rails can concentrate dieldrin in their tissues from residue levels in their food supply that are below detection limits of the present study.

All other organochlorines were either absent or occurred in small quantities in only a few samples (see footnotes, Tables 4-6). The infrequent occurrence and low concentration of other organochlorines indicate that the use of these persistent insecticides has not increased appreciably as a result of the cessation of DDT use.

The lull which followed 20 years of intensive spraying of DDT for mosquito control in Cape May County has been marked by rather rapid decreases in occurrence and concentration of ΣDDT in aquatic fauna. More information is needed for species in higher trophic levels such as fish-eating birds and carnivorous fish, but these forms should also begin to show decreased residue levels. Reproduction in the osprey (*Pandion haliaetus*) in Cape May County had been seriously depressed for several years, but it began to improve slightly in 1974 (*12*). However, heron eggs col-

lected in Cape May County in 1972 still contained rather high residue levels (*23*).

Acknowledgments

Authors gratefully acknowledge the important contribution of Fred A. Ferrigno, Sr., who aided in planning the study, assisted in collecting all the organisms in both 1967 and 1973, and reviewed the manuscript. We thank Aldeen Van Velzen who assisted in collecting in 1967 and Lee Widjeskog who assisted in 1973. Judy A. Hansen was very helpful in providing the data on spraying and we appreciate her cooperation. We also thank E. H. Dustman and Lucille Stickel for reviewing the manuscript.

LITERATURE CITED

(1) *Bailey, S., P. J. Bunyan, B. D. Rennison, and A. Taylor. 1969.* The metabolism of 1,1-Di(p-chlorophenyl-2,2,2-trichloroethane and 1,1-Di(p-chlorophenyl)-2,2-dichloroethane in the pigeon. Toxicol. Appl. Pharmacol. 14(*1*):13-22.

(2) *Bailey, S., P. J. Bunyan, B. D. Rennison, and A. Taylor. 1969.* The metabolism of 1,1-Di(p-chlorophenyl)-2,2-dichloroethylene and 1,1-Di(p-chlorophenyl)-2-chloroethylene in the pigeon. Toxicol. Appl. Pharmacol. 14(1):23-32.

(3) *Butler [illegible]. 1973.* Organochlorine residues in estuarine mollus[illegible]965-72—National Pesticide Monitoring Program. Pestic. [illegible]nit. J. 6(4):238–362.

(4) *Cromartie, E., W. L. Reichel, L. N. Locke, A. A. Belisle, T. E. Kaiser, T. G. Lamont, B. M. Mulhern, R. M. Prouty, and D. M. Swineford. 1975.* Residues of organochlorine pesticides and polychlorinated biphenyls and autopsy data for bald eagles, 1971-72. Pestic. Monit. J. 9(1):11-14.

(5) *Dziuk, L. J., and F. W. Plapp. 1973.* Insecticide resistance in mosquitofish from Texas. Bull. Environ. Contam. Toxicol. 9(1):15-19.

(6) *Edwards, C. A.* 1973. Persistent Pesticides in the Environment. CRC Press, Cleveland, Ohio. 170 pp.

(7) *Ferrigno, F., Sr. 1966.* They go up and down: population dynamics of the clapper rail. N. J. Outdoors 16(8):3-9.

(8) *Foehrenbach, J. 1972.* Chlorinated pesticides in estuarine organisms. J. Water Pollut. Control Fed. 44(4):619-624.

(9) *Ginsburg, J. M. 1950.* Chemicals used for mosquito control in New Jersey in 1949. Proc. 37th Annu. Meet. N. J. Mosq. Exterm. Assoc.: 69–75.

(10) *Henderson, C., A. Inglis, and W. L. Johnson. 1971.* Organochlorine insecticide residues in fish—fall 1969 (National Pesticide Monitoring Program). Pestic. Monit. J. 5(1):1-11.

(11) *Henderson, C., W. L. Johnson, and A. Inglis. 1969.* Organochlorine insecticide residues in fish (National Pesticide Monitoring Program). Pestic. Monit. J. 3(3):145-171.

(12) *Henny, C. J. 1976.* Research, management, and status of the osprey in North America. Paper presented at World Conference on Birds of Prey, Vienna, Austria, October 1-3, 1975. (Proceed., in press).

(13) *Jobbins, D. M. 1951.* Aerial spraying for mosquito control in New Jersey seashore counties. Proc. 38th Annu. Meet. N. J. Mosq. Exterm. Assoc.: 5-10.

(14) *Jobbins, D. M. 1953.* Airplane spraying for mosquito control along the Jersey shore, 1950-1952. Proc. 40th Annu. Meet. N. J. Mosq. Exterm. Assoc.: 197-201.

(15) *Jobbins, D. M. 1955.* Aircraft spraying for mosquito control—five years' operation in seashore counties. Proc. 42nd Annu. Meet. N. J. Mosq. Exterm. Assoc. 147-150.

(16) *Khan, M. A. Q., R. H. Stanton, and G. Reddy. 1973.* Detoxification of foreign chemicals by invertebrates. Pages 177-201 *in* M. A. Q. Khan and J. P. Bederka, Jr., eds. Survival in Toxic Environments. Academic Press, Inc., New York.

(17) *Lafferty, B. 1950.* The six-year supplemental program for mosquito control in Cape May County. Proc. 37th Annu. Meet. N. J. Mosq. Exterm. Assoc.: 184-187.

(18) *Lafferty, O. W. 1947.* An aerosol fog unit used for control of adult mosquitos in seashore communities. Proc. 34th Annu. Meet. N. J. Mosq. Exterm. Assoc.: 182-184.

TABLE 8. *Comparison of polychlorinated biphenyl residues in selected biota from salt marshes, Cape May County, New Jersey—1967 vs. 1973*

	Residues, ppm wet weight						
	1967			1973			
Species	N[1]	Geometric mean	Range	N[1]	Geometric mean	Range	Percent change
Clapper Rail	43	0.25[2]	—	27	0.65[2]	0.00-3.40	+160[3]
Sheepshead Minnow	5	1.31	0.60-4.30	5	0.16	0.13-0.18	− 88[3]
Mummichog	6	1.77	0.83-3.50	6	0.20	0.12-0.29	− 89[3]
Striped Killifish	3	1.38	0.41-2.80	6	0.18	0.14-0.22	− 87[3]
Fiddler Crab	5	0.16	0.09-0.25	6	0.16	0.10-0.27	0
Ribbed Mussel	5	0.15	0.05-0.36	6	0.09	0.0 -0.24	− 40
Periwinkle	1	0.72	—	6	0.14	0.14-0.30	− 81
Mud Snail	3	0.11	0.07-0.13	6	0.12	0.06-0.34	+ 9
Salt Marsh Snail	6	0.27	0.06-1.40	6	0.06	0.0 -0.13	− 78[3]

[1] For clapper rail, n = number of individuals; for all others, n = number of pooled samples.
[2] Geometric means were calculated by assuming an arbitrary value of 0.25 ppm for residues that could only be quantified as <0.5 ppm.
[3] Changes are significant at probability levels of 0.05 or less (two-tailed, Wilcoxen two-sample test).

(19) *Lamont, T.G., G. E. Bagley, and W. L. Reichel. 1970.* Residues of *o,p'*-DDD and *o,p'*-DDT in brown pelican eggs and mallard ducks. Bull. Environ. Contam. Toxicol. 5(3):231-236.

(20) *Matsumura, F. 1973.* Microbial degradation of pesticides. Pages 129-154 *in* M. A. Q. Khan and J. P. Bederka, Jr., eds. Survival in Toxic Environments. Academic Press, Inc., New York.

(21) *Mulhern, T. D. 1949.* A review for New Jersey for 1948. Proc. 36th Annu. Meet. N. J. Mosq. Exterm. Assoc.: 187–194.

(22) *Odum, W. E., G. M. Woodwell, and C. F. Wurster. 1969.* DDT residues absorbed from organic detritus by fiddler crabs. Science 164:576-577.

(23) *Ohlendorf, H. M., E. E. Klaas, and T. E. Kaiser. 1973.* Environmental pollution in relation to estuarine birds. Pages 53-81 *in* M. A. Q. Khan and J. P. Bederka, Jr., eds. Survival in Toxic Environments. Academic Press, Inc., New York.

(24) *Sokal, R. R., and F. J. Rohlf. 1969.* Biometry. W. H. Freeman and Co., San Francisco. 776 pp.

(25) *Van Velzen, A., and J. F. Kreitzer. 1975.* The toxicity of *p,p'*-DDT to the clapper rail. J. Wildl. Manage. 39(2):305-309.

(26) *Veith, G. D. 1975.* Baseline concentrations of polychlorinated biphenyls and DDT in Lake Michigan fish, 1971. Pestic. Monit. J. 9(1):21-29.

(27) *Woodwell, G. M., C. F. Wurster, Jr., and P. A. Isaacson. 1967.* DDT residues in an East Coast estuary: a case of biological concentration of a persistent insecticide. Science 156(3776):821-824.

GENERAL

Monitoring Agricultural Insecticides in the Cooperative Cotton Pest Management Program in Arizona, 1971—First-Year Study [1]

Donald W. Woodham, [2] Hugh F. Robinson,[3] Robert G. Reeves,[4] Charles A Bond,[5] and Harry Richardson[5]

ABSTRACT

A county-wide pest management program was initiated in Pinal County, Ariz., in 1971 to improve ecologically, economically, and socially the system for protecting cotton from insect pests. Included in this program was a plan to determine the environmental impact of any resulting pesticide load in the environment. Monitoring studies were developed for the assay of insecticide residues in soil, sediment, water, and biological materials. This report presents results of the first year's study and analytical methodology used to achieve those results.

Introduction

A county-wide cotton pest management program was initiated in Pinal County, Ariz., in 1971 as a cooperative endeavor of the U.S. Department of Agriculture—Animal and Plant Health Inspection Service (USDA-APHIS), Cooperative Extension Service and the University of Arizona Department of Entomology. The main objective of this pilot study was to establish a more ecologically, economically, and socially acceptable system for protecting cotton from insect pests.

During the first year of the study various aspects of this pest management program were organized and executed, including an environmental impact analysis program. This report concerns results obtained from that program.

Both biotic (birds, snakes, lizards, frogs, fish) and abiotic (soil, sediment, water) samples were collected and analyzed for pesticide residues to determine what impact, if any, the application of currently used pesticides has on the environment.

Sampling Procedures

The sample collection and analysis programs were designed to obtain comparisons of residues within and outside the project areas before treatment and after harvest. The effects of pesticide treatments on pond water and aquatic life were also determined by collecting samples of water, sediment, and aquatic organisms from ponds near the cotton sites.

Biotic samples included birds, toads and frogs, snakes, lizards, aquatic and terrestrial insects, and fish, i.e., minnows. Abiotic samples were pond water, pond sediment, and soil from cottonfields.

Cottonfields in the Pest Management Program were selected to provide at least one site in each cotton-growing area of Pinal County, further restricted to areas near or adjacent to permanent or semipermanent water supplies. Sites outside the program were chosen for their locations near selected cotton sites. Insecticide treatment information was obtained from each sampling site when available (Table 1).

Random soil samples were collected within and outside program areas utilizing a core sampling device described previously by Woodham et al. (*5*). All soil was composited, screened, weighed, stored, and shipped according to those procedures.

Sediment samples were collected randomly with an Eckman dredge, composited, subsampled, stored, and shipped according to Woodham (*5*). Approximately 10 drags of the dredge were required for each sample; great care was taken to collect all possible fine and coarse sediment and silt material.

[1] U.S. Department of Agriculture—Animal and Plant Health Inspection Service, Plant Protection and Quarantine Programs, Brownsville, Tex.

[2] USDA, APHIS, PPQ, Staff Officer, New Pest Detection and Survey Staff, 659 Federal Center Bldg., Hyattsville, Md. 20782. Reprints available from this address.

[3] USDA, APHIS, PPQ, Sacramento, Calif.

[4] USDA, APHIS, PPQ, Chemist, Gypsy Moth Laboratory, Otis Air Force Base, Mass.

[5] USDA, APHIS, PPQ, Chemist, Environmental Monitoring Laboratory, Gulfport, Miss.

TABLE 1. *Pesticide treatment information, Pinal County, Arizona—1971*

Site	Application Date	Pesticide	Actual amount/ acre
1A	3/25	Strobane/methyl parathion	1/3 gal
2A	7/14	Ethyl parathion/methyl parathion	1/3 gal
	7/24	Ethyl parathion/methyl parathion	1 pt
	7/30	Ethyl parathion/methyl parathion	1-1/2 pt
	8/05	Ethyl parathion/methyl parathion	1-1/2 pt
	8/12	Ethyl parathion/methyl parathion	1 pt
	8/20	Ethyl parathion/methyl parathion	1-1/2 pt
3A	—	NA	—
4A	—	NA	—
5A	7/23	Dimethoate	NA
	8/06	Malathion	NA
	8/15	Ethyl parathion	NA
	8/22	Methyl parathion/toxaphene	NA
6A	7/23	Sevin-molasses	2 lb
	7/30	Sevin-molasses	2 lb
	8/04	Sevin-molasses	2 lb
	8/11	Sevin-molasses	2 lb
	8/21	Methyl parathion/toxaphene	1 qt
	8/27	Methyl parathion	3-1/4 qt
		Toxaphene	1-1/2 qt
7A	7/16	Methyl parathion/toxaphene	1-1/2 pt
	7/25	Methyl parathion/toxaphene	1-1/2 pt
	8/02	Methyl parathion/toxaphene	1/2 gal
	8/09	Methyl parathion/toxaphene	1/3 gal
	8/12	Ethyl-methyl parathion	1 pt
		Endrin	1 pt
	8/16	Methyl parathion/toxaphene	1/3 gal
	8/27	Methyl parathion/toxaphene	1/3 gal
	9/11	Ethyl-methyl parathion	1 pt
		Ethyl parathion/toxaphene	1/3 gal
	9/14	Ethyl-methyl parathion	1/6 gal
		Endrin	1 qt
	8/23	Ethyl-methyl parathion	1/6 gal
8A	7/17	Ethyl parathion	1 qt
		Toxaphene	1 qt
	7/28	Ethyl-methyl parathion	1 pt
	8/22	Ethyl-methyl parathion/toxaphene	1/3 gal
	9/01	Ethyl parathion/toxaphene	1/3 gal
9A	7/26	Ethyl parathion/methyl parathion	1/3 gal
	7/30	Ethyl parathion/methyl parathion	1/3 gal
	8/07	Methyl parathion/toxaphene	1/3 gal
	8/10	Methyl parathion/toxaphene	1/3 gal
	8/15	Methyl parathion/toxaphene	1/3 gal
	8/25	Methyl parathion/toxaphene	1 qt
	8/29	Methyl parathion/toxaphene	1 qt
10A	—	NA	—

NA = not available.

Random water samples were collected from tailwater ponds, irrigation ditches, or canals as near as possible to the corresponding sediment sampling sites. By varying the depth of the dredge except for bottom samples, a representative gallon of pond water was collected and stored in sealed gallon glass bottles.

Birds, mammals, lizards, frogs, toads and snakes were collected by shooting with either a .22 caliber rifle with birdshot or a 12-gauge shotgun, within the various sampling sites. Minnows and other fish were caught in a small-mesh minnow seine. Water beetles were collected from sediment samples and grasshoppers were caught in the fields with hand nets. Crickets and some ants were gathered by hand; the remaining ants were collected with an aspirator sampling device.

Soil, sediment and water samples were stored at approximately 40°F in a refrigerator pending shipment to the USDA Environmental Quality Laboratory, Brownsville, Tex. Biological samples were stored at 0°F pending airmail shipment in styrofoam biomailers with dry ice. Once samples were received in the laboratory, they were immediately unpacked; biological samples were stored again in a 0°F freezer, and soil, sediment, and water were stored at 40°C pending residue analysis.

Preparation of Samples

EXTRACTION

Representative 300-g soil samples were extracted with 600 ml of a 3:1 (v/v) hexane-isopropyl alcohol solvent mixture in half-gallon Mason jars on a concentric rotator for 4 hours as described previously by Stevens et al. (*4*). After rotation, 300 ml of the extract was filtered into 1000-ml separatory funnels where the alchohol was removed by washing three times with equal volumes of distilled water. The hexane extract was dried by filtering through a layer of anhydrous granular sodium sulfate into amber sample bottles. The bottles were sealed and refrigerated pending gas-chromatographic (GC) analysis. Soil extracts did not normally require cleanup before analysis.

Sediment samples were prepared and stored as soil samples had been, except that 250 g anhydrous granular sodium sulfate was added to absorb excess water. As usual, sediment samples contained excessive amounts of sulfur which interfere with analyses for organophosphate and chlorinated hydrocarbon residues. These samples were treated utilizing the sulfur removal procedure of Schultzmann et al. (*3*).

Water samples were extracted by shaking representative 500-g subsamples in 1000-ml separatory funnels three times with fresh 100-ml portions of nanograde (Mallinckrodt, Inc.) dichloromethane. The organic layers were filtered through a layer of granular anhydrous sodium sulfate to remove entrained water into 500-ml Erlenmeyer flasks. One ml of a 0.01 percent Nujol in hexane solution and glass beads were added and the solvent was evaporated through Snyder columns to approximately 5 ml on a warm water bath: 40°-50° C. One hundred ml nanograde hexane was added through the Snyder columns and the solvent was again evaporated to approximately 5 ml. The concentrated extracts were transferred to 15-ml graduated centrifuge tubes which were stoppered; the volume was adjusted to 12.5 ml with nanograde hexane. Samples were refrigerated pending GC analysis. Water samples did not normally require cleanup before residue analysis.

Larger biological samples such as rabbits, birds, lizards, snakes, and fish were prepared according to the procedure used by Woodham et al. (*7*). Samples were thoroughly ground in a Hobart food grinder; then representative 25-g subsamples were weighed into 1000-ml Waring blendor jars with 150 ml of a 3:1 mixture of nanograde hexane: isopropyl alcohol and blended at low speed for 2 minutes. The macerated materials were transferred into half-gallon Mason jars with 250 ml of the hexane: isopro-

pyl alchohol mixture and the jars were sealed and rotated concentrically 4 hours. Extracts were filtered through glass wool into 1000-ml separatory funnels where the alchohol was removed with three successive washings of equal volumes of distilled water; the aqueous layers were discarded. Hexane extracts were filtered through layers of anhydrous granular sodium sulfate into graduated cylinders where 100-ml aliquots were collected. The aliquots were transferred into amber sample bottles, sealed, and refrigerated pending cleanup.

Smaller biological samples, mainly insects, weighing 25 g or less were weighed and transferred into micro-blendor cups with 50-ml nanograde isopropyl alchohol and blended for 2 minutes at high speed. The macerates were sealed into quart Mason jars with 150 ml nanograde hexane and rotated concentrically 4 hours at 30 rpm. Extracts were filtered into 500-ml separatory funnels where all alcohol and water were removed by three successive washings with equal portions of distilled water. Extracts were dried and refrigerated.

CLEANUP

Biological sample extracts were cleaned by liquid:liquid partitioning between two immiscible organic solvents, hexane:acetonitrile, to remove fats and oils. The procedure, described previously by Woodham et al. (*5*), involved transfer of 10-g aliquots of the extracts into 125-ml Erlenmeyer flasks and concentrating to approximately 25 ml on a warm water bath using a gentle stream of dry air to facilitate evaporation of the solvent. The concentrated extracts were diluted to exactly 50 ml with nanograde hexane and transferred into 250-ml separatory funnels and partitioned three times with 100-ml portions of nanograde acetonitrile saturated with hexane. The hexane layers were discarded and the combined acetonitrile layers were collected in 500-ml separatory funnels and washed once with 20 ml nanograde hexane saturated with acetonitrile to remove any trace of fats or oils. The acetonitrile fraction was divided into equal portions for further processing.

For organophosphates, one portion of the acetonitrile fraction was transferred to 250-ml Erlenmeyer flasks, 1 ml of 0.01 percent solution of Nujol in hexane and glass beads were added, and the solvent was evaporated to approximately 5 ml on hotplates through Snyder columns. The concentrated extracts were transferred to 15-ml graduated centrifuge tubes where the volume was adjusted to exactly 12.5 ml with nanograde acetonitrile. The stoppered tubes were refrigerated pending GC analysis.

For chlorinated hydrocarbons, the remaining portion was transferred into 250-ml Erlenmeyer flasks, glass beads and 1 ml of a 0.01 percent Nujol in hexane solution were added, and the solvent was evaporated to approximately 10 ml on hotplates through Snyder columns. The flasks were cooled and 100 ml hexane was added through the Snyder columns and the evaporation procedure described previously was repeated on a hot water bath. This step was repeated two additional times, and the flasks were sealed and refrigerated pending florisil cleanup.

FLORISIL CLEANUP

Florisil chromatographic cleanup columns have been described previously (*5*). Only two fractions were collected from the columns in the present study because organophosphate residue analyses were conducted on the partitioned samples. Aliquots from the extraction procedure were transferred into the hexane prewashed columns and eluted with 100 ml nanograde hexane, then with 100 ml 15 percent diethyl ether in hexane; each eluate was collected in separate 250-ml Erlenmeyer flasks. The solvent was evaporated and stored as described previously (*5*). The less polar pesticide residues such as lindane, heptachlor, aldrin, DDE, TDE, DDT, and toxaphene were contained in the first fraction; the second fraction contained the more polar residues such as dieldrin, endrin, and heptachlor epoxide.

Gas-Chromatographic Analysis

Analysts used MT-220 gas chromatographs equipped with Ni-63 high-temperature electron-capture detectors and a Melpar Flame Photometric Detector (FPD). The FPD detector was designed to operate simultaneously in the sulfur (394 mu) and the phosphorous (526 mu) modes.

Operating parameters were:

Columns: 6-ft-by-$^1/_4$-in.-glass packed with 3 percent DC-200 on 100/200-mesh Gas-Chrom Q; 3 percent OV-1 on 80/100-mesh Chromosorb-W; 5 percent QF-1 on 100/120-mesh Gas-Chrom Q; and 11 percent mixture of 1.95 percent QF-1 : 1.5 percent OV-17 on 80/100-mesh Gas-Chrom Q. A 3 percent DC-200 column as described in (*1*) was also used for the FPD analysis of organophosphate residues.

Temperatures (isothermal): Columns: 200° C
Injector: 250° C
Detectors EC 300° C
FPD 200° C

Gas flow rates: Nitrogen (carrier) 80 ml/min
Air 40 ml/min
Hydrogen 75 ml/min
Oxygen 20 ml/min

Recorder chart speed was 30 in./hr; sensitivity was adjusted to obtain approximately half full-scale deflection of the recorder pen with a 0.05-ng injection of aldrin on the electron-capture detectors and 1.50 ng of ethyl parathion

on the FPD detector. Calculations were based on peak heights obtained from analytical standards compared with identical peaks in the samples. Lower limit of sensitivity was 0.01 ppm for organophosphates and chlorinated hydrocarbon pesticides except in water, whose lower limit was 0.01 ppb.

Toxaphene was analyzed using the GC method of Hawthorne and Dawsey (USDA Environmental Monitoring Laboratory, Gulfport, Miss., 1972: personal communication). Extraction, cleanup, and other processing steps were identical to those used for the organochlorine and organophosphate pesticide residues. The quantitation procedure involved comparing heights of the four major peaks in a toxaphene standard with heights of those peaks in the environmental samples. Gas-chromatographic operating parameters were identical to those described previously for organochlorine and organophosphate pesticides on the 3 percent DC-200 column. When minor peaks interfered with the four major peaks of toxaphene, as few as two such peaks could be used for accurate quantitation. The lower limit of sensitivity of toxaphene was 0.05 ppm except for water, whose limit was 0.05 ppb.

Doubtful pesticide peaks were confirmed by several methods described in previous publications: thin-layer chromatography, Schutzmann et al. (*2*); partitioning coefficients (*p*-values), Bowman and Beroza (*1*); chemical means, Woodham, et al. (*4*); and multiple column methods. Peaks which were not at least twice the interference level were rejected.

Recovery

A series of control samples extracted, purified, and analyzed in identical manner as the unknowns, was included with each group of samples. These controls included a solvent check, nonfortified sample and a sample fortified with known amounts of the suspected pesticides. These controls were necessary in order to monitor possible contamination of solvents, determine residues in nonfortified sample material, and determine extraction and analytical efficiency of the entire procedure. No interfering peaks were detected in the solvents; pesticide peaks detected in unfortified samples were deducted from those in fortified samples to obtain recovery percentages. Average recovery values are listed in Table 2.

Results and Discussion

Table 3 presents residue data for the soil samples collected within and outside the program areas, before pesticide treatments began and after harvest. The organophosphate, ethyl parathion, was detected in trace amounts, 0.13 ppm and 0.03 ppm, in soil from sites 2A and 3A, respectively, within the program area after harvest. No organophosphate residues were detected in soil collected before the pesticide treatments or in soil outside the program area. Residues of ethyl parathion were detected in soil from sites 1B, 2B, 3B, 5B, 7B, and 8B at harvest outside program areas. Residues in soil from these sites apparently resulted from direct pesticide application to cotton crops.

Organochlorine pesticides were detected in all soils before pesticide treatments and after harvest, within and outside program areas. Before pesticide application, residues ranged from 0.29 to 1.43 ppm *p,p'*-DDE, 0.11 to 1.49 ppm *p,p'*-DDT, and <0.05 to 3.94 ppm toxaphene in soil from sites within the program area. After harvest, residues ranged from 0.21 to 0.76 ppm *p,p'*-DDE, 0.11 to 1.33 ppm *p,p'*-DDT, and 1.18 to 5.18 ppm toxaphene in the soil. Outside the program area, the same organochlorine pesticide residues were detected, ranging from 0.50 to 1.82 ppm *p,p'*-DDE, 0.25 to 1.53 ppm *p,p'*-DDT, and <0.05 to 2.68 ppm toxaphene in pretreatment soil. At harvest, organochlorine pesticide residues ranged from 0.33 to 1.24 ppm *p,p'*-DDE, 0.31 to 0.86 ppm *p,p'*-DDT, and 2.41 to 4.04 ppm toxaphene in soil collected outside the program area. The decline in *p,p'*-DDE residues was apparently due to cultivation practices on the various sites.

Residue data for pesticides in biological samples are given in Table 4. Ethyl parathion residues ranged from 0.03 ppm in a frog sample collected before treatment within the program area and a rabbit sample collected before treatment outside the treatment area to 1.24 ppm in a sample of minnows collected before treatment within the program area.

Organochlorine pesticide residues were detected in all biological samples, predominantly *p,p'*-DDT and other isomers of DDE, DDT, and TDE. Residue patterns were similar among samples from inside and outside program areas although concentrations were generally lower in samples from outside the program.

Various pretreatment samples collected inside program areas had residues of heptachlor epoxide, <0.01-0.06 ppm; β-BHC, <0.01-0.05 ppm; dieldrin, <0.01-0.55 ppm; *o,p'*-DDE, <0.01-1.52 ppm; *p,p'*-DDE, 0.03-45.52 ppm; *o,p'*-TDE, <0.01-0.60 ppm; *p,p'*TDE, <0.01-1.73 ppm; *o,p'*-DDT, <0.01-0.17 ppm; and *p,p'*-DDT, <0.01-2.36 ppm. Residues in post-treatment samples produced generally the same pattern of pesticides, but at generally lower levels.

Pretreatment samples collected outside program areas showed residues of β-BHC, <0.01-0.47 ppm; heptachlor epoxide, <0.01-0.07 ppm; dieldrin, <0.01-4.68 ppm; *o,p'*-DDE, <0.01-0.31 ppm; *p,p'*-DDE, 0.02-57.62 ppm; *o,p'*-TDE, <0.01-0.16 ppm; *p,p'*-TDE, <0.01-1.36 ppm; *o,p'*-DDT, <0.01-0.31 ppm; and *p,p'*-DDT, <0.01-2.12 ppm, in such varied samples as frogs, toads, lizards, birds, and fish. Post-treatment samples from outside program areas generally produced similar residue patterns with lower concentrations; some exceptions occurred, how-

ever, such as an increase in *p,p'*-DDE residues to a range of 0.04-76.30 ppm in post-treatment bird samples.

Residues of pesticides used during the 1971 growing season in the Arizona Cotton Pest Management Program did not accumulate, except for toxaphene in soil samples. An increase of toxaphene residues was noted in harvest soil inside and outside program areas. The increase in residues outside program areas was apparently due to pesticide treatments during 1971. No toxaphene residue were detected in sediment, water, or biological samples inside or outside the program areas, which indicates that this chlorinated camphene is not transferred to the biological food chain.

TABLE 2. *Average pesticide recoveries from fortified environmental sample materials, Pinal County, Arizona—1971*

Sample Material	Recovery, %																		
	Ethyl Parathion	Methyl Parathion	Malathion	Methyl Trithion	Ethion	β-BHC	γ-BHC	Heptachlor	Aldrin	Heptachlor Epoxide	*o,p'*-DDE	*p,p'*-DDE	Dieldrin	Endrin	*o,p'*-TDE	*p,p'*-TDE	*o,p'*-DDT	*p,p'*-DDT	Toxaphene
Soil	102.2	96.4	101.5	100.6	107.3	91.0	89.0	84.1	89.4	94.8	79.7	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0
Sediment	93.0	80.0	86.0	90.0	89.0	85.5	94.2	86.1	80.8	91.1	85.5	85.5	85.5	79.4	77.0	85.5	87.7	88.6	85.5
Water	89.8	91.3	89.2	78.9	99.6	93.6	92.4	93.0	89.9	94.6	95.6	93.5	93.1	95.9	95.0	93.4	92.9	93.5	93.6
Lizards and Snakes	88.4	85.4	82.6	82.6	74.1	100.0	97.0	100.9	103.5	82.9	71.5	82.9	82.9	96.8	86.0	80.5	83.3	80.8	82.9
Frogs, Toads and Polliwogs	95.8	88.4	83.4	97.8	96.3	100.0	97.0	101.2	95.1	101.2	76.0	76.0	96.8	96.8	76.0	76.0	76.0	76.0	98.0
Birds, Nestlings and Eggs	93.5	94.8	97.0	93.6	95.2	100.0	75.6	86.4	69.0	85.8	93.2	89.0	85.8	91.9	82.3	92.3	88.7	92.9	85.8
Fish and Freshwater Clams	86.4	96.0	84.6	60.8	72.6	100.0	78.9	72.7	58.4	81.4	100.2	100.2	78.9	76.3	104.8	109.1	91.5	95.5	100.2
Insects	95.7	103.3	106.3	101.8	99.8	100.0	100.5	88.6	76.2	100.5	93.6	88.9	96.5	102.7	104.0	98.7	101.0	97.0	95.7

TABLE 3. *Pesticide residues in soil from pest management area, Pinal County, Arizona—1971*

Site	Sampling Date[1]	Residues, ppm								
		Ethyl Parathion[2]	Dieldrin	*o,p'*-DDE	*p,p'*-DDE	*o,p'*-TDE	*p,p'*-TDE	*o,p'*-DDT	*p,p'*-DDT	Toxaphene
Program Sites										
1A	7/13	<0.01	<0.01	<0.01	1.42	<0.01	<0.01	<0.01	1.00	2.31
	11/24	<0.01	<0.01	<0.01	0.53	<0.01	<0.01	<0.01	0.60	3.61
2A	6/25	<0.01	<0.01	<0.01	1.33	<0.01	<0.01	<0.01	1.33	1.90
	11/24	0.13	<0.01	<0.01	0.67	<0.01	<0.01	<0.01	0.67	2.06
3A	7/13	<0.01	<0.01	<0.01	0.65	<0.01	<0.01	<0.01	1.06	1.97
	11/29	0.03	<0.01	<0.01	0.68	<0.01	<0.01	<0.01	0.68	2.52
4A	7/06	<0.01	<0.01	<0.01	1.43	<0.01	<0.01	<0.01	1.49	3.94
	11/23	<0.01	<0.01	<0.01	0.72	<0.01	<0.01	<0.01	0.92	4.71
5A	7/06	<0.01	<0.01	<0.01	0.61	<0.01	<0.01	<0.01	0.61	2.51
	11/23	<0.01	<0.01	<0.01	0.38	<0.01	<0.01	<0.01	0.38	2.57
6A	7/13	<0.01	<0.01	<0.01	0.29	<0.01	<0.01	<0.01	0.11	0.85
	11/30	<0.01	<0.01	<0.01	0.21	<0.01	<0.01	<0.01	0.11	1.18
7A	7/09	<0.01	<0.01	<0.01	1.00	<0.01	<0.01	<0.01	1.08	3.20
	11/22	<0.01	<0.01	<0.01	0.76	<0.01	<0.01	<0.01	1.07	5.18
8A	7/12	<0.01	<0.01	<0.01	0.58	<0.01	<0.01	<0.01	1.39	0.05
	12/02	<0.01	<0.01	<0.01	0.39	<0.01	<0.01	<0.01	0.99	1.39
9A	7/13	<0.01	<0.01	<0.01	0.59	<0.01	<0.01	<0.01	0.45	0.86
	12/01	<0.01	<0.01	<0.01	0.33	<0.01	<0.01	<0.01	0.35	2.21
10A	7/02	<0.01	<0.01	<0.01	0.70	<0.01	<0.01	<0.01	0.77	2.48
Nonprogram Sites										
1B	7/17	<0.01	<0.01	<0.01	1.29	<0.01	<0.01	<0.01	0.36	1.83
	11/29	0.10	<0.01	<0.01	1.24	<0.01	<0.01	<0.01	0.33	2.41
2B	7/16	<0.01	<0.01	<0.01	1.64	<0.01	<0.01	<0.01	0.32	0.05
	11/24	0.02	<0.01	<0.01	0.79	<0.01	<0.01	<0.01	0.54	2.75
3B	7/23	<0.01	<0.01	<0.01	0.85	<0.01	<0.01	<0.01	0.27	1.61
	11/29	0.05	<0.01	<0.01	0.58	<0.01	<0.01	<0.01	0.43	3.52
4B	7/16	<0.01	<0.01	<0.01	0.50	<0.01	<0.01	<0.01	0.29	1.45
5B	7/15	<0.01	<0.01	<0.01	0.66	<0.01	<0.01	<0.01	0.25	1.09
	11/23	0.06	<0.01	<0.01	0.33	<0.01	<0.01	<0.01	0.31	3.52
6B	7/16	<0.01	<0.01	<0.01	1.82	<0.01	<0.01	<0.01	0.72	1.93
	11/30	<0.01	<0.01	<0.01	0.86	<0.01	<0.01	<0.01	0.76	3.02
7B	7/22	<0.01	<0.01	<0.01	1.73	<0.01	<0.01	<0.01	0.33	2.11
	11/22	<0.01	<0.01	<0.01	0.67	<0.01	<0.01	<0.01	0.39	4.04
8B	7/21	<0.01	<0.01	<0.01	1.10	<0.01	<0.01	<0.01	0.37	1.57
	11/23	0.02	<0.01	<0.01	0.54	<0.01	<0.01	<0.01	0.46	2.46
9B	7/14	<0.01	<0.01	<0.01	1.53	<0.01	<0.01	<0.01	1.53	2.68
	12/01	<0.01	<0.01	<0.01	0.65	<0.01	<0.01	<0.01	0.65	3.64
10B	7/21	<0.01	<0.01	<0.01	1.65	<0.01	<0.01	<0.01	0.87	1.82
	12/02	<0.01	<0.01	<0.01	0.65	<0.01	<0.01	<0.01	0.86	3.43

NOTE: Residue data corrected for pesticide recovery from fortified samples and for moisture content of oven-dried samples. Lower limits of sensitivity = 0.01 ppm, except for toxaphene, which was 0.05 ppm.

[1] Postharvest samples were not collected from sites listed.

[2] No residues of methyl parathion, malathion, methyl trithion, ethion, or other organophosphates exceeding the lower limits of sensitivity (0.01 ppm) were detected.

Conversely, residues of dieldrin, b-BHC, and heptachlor epoxide which did not appear in soil, sediment, or water were found in all biological materials sampled except for rats and rabbits. These residues may have resulted from pesticide treatments in previous years.

Residues of DDT, DDE, and TDE which appeared in soil and biological samples but not in sediment and water, decreased between the spring and fall samplings. The passage of an Arizona State ordinance in 1969 banning the use of DDT apparently contributed to this decline.

In order to determine the trend of accumulation or decline of pesticide residues, a longer study must be conducted. The present study will be continued for a minimum of 3 years before any baseline may be established; a more likely estimate is 5 years. Such a long-term study must be conducted to obtain residue data which can be used to project trends and draw conclusions pertaining to the impact of the Pinal County pest management system and its reduced pesticide load.

Acknowledgments

Authors wish to express gratitude to a number of workers who furnished expert assistance in sample collections and processing for this study. Among these are Leon Moore and Mike Lindsey, Cooperative Extension Service, for technical assistance and advice, and L. D. McCorkingdale, State Entomologist, for assistance in designing the program. Without their help the program could not have achieved its present success. Appreciation is also expressed to Stephen Warnick and staff, Intermountain Laboratories, Inc., Salt Lake City, Utah, for their expert assistance in performing residue analyses on certain biological samples.

LITERATURE CITED

(1) *Bowman, M.C., and M. Beroza. 1965.* Extraction p-values of pesticides and related compounds in six binary solvent systems. J. Assoc. Offic. Agric. Chem. 48(2):943-952.

(2) *Schutzmann, R. L., W. F. Barthel, and J. A. Warrington. 1966.* Cleanup and confirmation of identity of pesticide residues by thin-layer chromatography. Part I: Soil, Water, and Sediment. USDA-ARS, 81-12. 13 pp.

(3) *Schutzmann, R. L., D. W. Woodham, and C. W. Collier. 1971.* Removal of sulfur in environmental samples prior to gas chromatographic analysis for pesticide residues. J. Assoc. Offic. Agric. Chem. 54(5):1117-1119.

(4) *Stevens, L. J., C.W. Collier, and D. W. Woodham. 1970.* Monitoring pesticides in soils from areas of regular, limited, and no pesticide use. Pestic. Monit. J. 4(3):145-164.

(5) *Woodham, D.W., R. R. Edwards, R. G. Reeves, and R. L. Schutzmann. 1973.* Total toxic aldicarb residues in soil, cottonseed and cotton lint following a soil treatment with the insecticide on the Texas high plains. J. Agr. Food Chem. 21(2):303-307.

(6) *Woodham, D. W., C. D. Loftis, and C. W. Collier. 1972.* Identification of the gas chromatographic dieldrin and endrin peaks by chemical conversion. J. Agr. Food Chem. 20(1):163-165.

TABLE 4. *Pesticide residues in biological samples from Cotton Pest Management Project, Pinal County, Arizona—1971*

Site	Sampling Date	Sample Material	Residues, ppm									
			Ethyl Parathion[1]	β-BHC	Heptachlor Epoxide	Dieldrin	*o,p'*-DDE	*p,p'*-DDE	*o,p'*-TDE	*p,p'*-TDE	*o,p'*-DDT	*p,p'*-DDT
			Program Samples									
Frogs and Toads												
1A	7/13	Frogs	0.03	0.01	< 0.01	0.02	0.02	7.01	0.01	0.04	0.01	0.05
	10/14	Frogs	<0.01	<0.01	<0.01	0.02	<0.01	9.15	<0.01	<0.01	<0.01	0.30
	10/14	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	1.93	<0.01	<0.01	<0.01	0.10
2A	10/12	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	1.43	<0.01	<0.01	<0.01	0.20
4A	7/20	Frogs	<0.01	<0.01	0.01	0.01	0.04	6.76	0.02	0.21	0.07	0.39
	10/12	Frogs	<0.01	<0.01	<0.01	<0.01	<0.01	17.60	<0.01	<0.01	<0.01	1.47
	7/20	Toads	<0.01	0.02	0.06	0.10	0.12	45.52	0.60	1.01	0.32	2.50
	10/12	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	12.39	<0.01	<0.01	<0.01	1.46
5A	7/13	Frogs	<0.01	<0.01	<0.01	<0.01	0.01	4.19	0.01	0.02	<0.01	0.02
	10/18	Frogs	<0.01	<0.01	<0.01	<0.01	<0.01	24.84	<0.01	<0.01	<0.01	0.99
6A	10/19	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	4.59	<0.01	<0.01	<0.01	0.51
7A	7/12	Toads	<0.01	0.01	0.02	0.01	0.09	8.34	0.10	0.22	0.17	0.53
	10/15	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	3.05	<0.01	<0.01	<0.01	0.63
	10/15	Frogs	<0.01	<0.01	<0.01	<0.01	<0.01	27.01	<0.01	<0.01	<0.01	0.26
8A	7/20	Frogs	<0.01	<0.01	<0.01	0.03	0.03	4.61	0.03	0.06	0.05	0.38
	10/20	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	0.29	<0.01	<0.01	<0.01	0.03
9A	10/20	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	0.98	<0.01	<0.01	<0.01	0.32
10A	7/18	Toads	<0.01	0.05	0.03	0.55	0.12	37.62	0.24	0.84	0.36	2.36
	10/21	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	11.12	<0.01	<0.01	<0.01	4.44
	10/21	Frogs	<0.01	<0.01	<0.01	<0.01	<0.01	2.95	<0.01	<0.01	<0.01	0.57
Fish												
1A	7/13	Minnows	1.24	0.04	0.06	0.06	1.19	13.07	<0.01	1.73	0.12	0.64
	10/14	Minnows	<0.01	<0.01	<0.01	<0.01	<0.01	17.42	<0.01	<0.01	<0.01	<0.01
3A	10/15	Minnows	<0.01	<0.01	<0.01	<0.01	<0.01	3.58	<0.01	<0.01	<0.01	<0.01
5A	7/13	Minnows	<0.01	0.01	0.02	0.04	1.24	8.71	<0.01	0.02	0.02	0.10
6A	7/18	Minnows	0.08	0.03	0.06	0.07	1.52	24.22	<0.01	2.30	0.07	1.48
	10/19	Minnows	<0.01	<0.01	<0.01	<0.01	<0.01	0.60	<0.01	<0.01	<0.01	<0.01

(Continued next page)

TABLE 4 (cont'd.). *Pesticide residues in biological samples from Cotton Pest Management Project, Pinal County, Arizona—1971*

Site	Sampling Date	Sample Material	Residues, ppm									
			Ethyl Parathion[1]	β-BHC	Heptachlor Epoxide	Dieldrin	o,p'-DDE	p,p'-DDE	o,p'-TDE	p,p'-TDE	o,p'-DDT	p,p'-DDT
			Program Samples									
Birds												
1A	7/13	Mourning Dove	<0.01	<0.01	<0.01	<0.01	<0.01	0.35	<0.01	0.01	<0.01	0.01
	10/14	Mourning Dove	<0.01	<0.01	<0.01	<0.01	<0.01	0.65	<0.01	<0.01	<0.01	<0.01
2A	7/19	Mourning Dove	<0.01	<0.01	<0.01	0.01	0.01	0.75	0.01	0.01	0.01	0.02
	10/12	Mourning Dove	<0.01	<0.01	<0.01	<0.01	<0.01	0.20	<0.01	<0.01	<0.01	<0.01
	7/19	Nestlings	<0.01	<0.01	<0.01	<0.01	0.01	0.50	0.01	0.01	0.01	0.01
3A	7/17	Whitewing Dove	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01
	10/14	Dove	<0.01	<0.01	<0.01	<0.01	<0.01	0.81	<0.01	<0.01	<0.01	<0.01
	10/14	Sparrow	<0.01	<0.01	<0.01	<0.01	<0.01	0.34	<0.01	<0.01	<0.01	<0.01
	7/17	Mourning Dove	<0.01	0.01	<0.01	0.09	0.02	2.87	<0.01	0.04	0.01	0.11
5A	7/18	Wren	<0.01	0.01	<0.01	0.02	0.02	6.59	<0.01	0.05	<0.01	0.11
	10/18	Woodpecker	<0.01	<0.01	<0.01	<0.01	<0.01	0.70	<0.01	<0.01	<0.01	<0.01
	10/18	Sparrows	<0.01	<0.01	<0.01	<0.01	<0.01	1.94	<0.01	<0.01	<0.01	<0.01
	10/18	Mourning Dove	<0.01	<0.01	<0.01	<0.01	<0.01	2.16	<0.01	<0.01	<0.01	<0.01
6A	10/19	Owl	<0.01	<0.01	<0.01	<0.01	<0.01	8.13	<0.01	<0.01	<0.01	<0.01
	10/19	Mourning Dove	<0.01	<0.01	<0.01	<0.01	<0.01	0.15	<0.01	<0.01	<0.01	<0.01
	10/19	Sparrows	<0.01	<0.01	<0.01	<0.01	<0.01	0.45	<0.01	<0.01	<0.01	<0.01
7A	7/12	Dove	<0.01	<0.01	<0.01	<0.01	0.01	-1.01	0.01	<0.01	<0.01	0.02
	10/15	Mourning Dove	<0.01	<0.01	<0.01	<0.01	<0.01	1.58	<0.01	<0.01	<0.01	<0.01
	7/12	Wren	<0.01	<0.01	<0.01	<0.01	0.07	3.04	<0.01	0.02	0.01	0.02
	10/15	Mexican Dove	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
	10/15	Finch	<0.01	<0.01	<0.01	<0.01	<0.01	5.78	<0.01	<0.01	<0.01	<0.01
8A	7/20	Wren	<0.01	<0.01	<0.01	<0.01	0.01	0.96	<0.01	<0.01	0.01	<0.01
	7/20	Sparrow	<0.01	0.01	<0.01	<0.01	0.02	8.38	<0.01	0.02	<0.01	0.02
	12/02	Inca Doves	<0.01	<0.01	<0.01	<0.01	<0.01	0.47	<0.01	<0.01	<0.01	<0.01
	10/20	Woodpeckers	<0.01	<0.01	<0.01	<0.01	<0.01	0.22	<0.01	<0.01	<0.01	<0.01
	10/20	Redheaded Woodpecker	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
10A	7/18	Mourning Dove	<0.01	<0.01	<0.01	<0.01	<0.01	0.63	<0.01	0.01	<0.01	0.06
	10/21	Mourning Dove	<0.01	<0.01	<0.01	<0.01	<0.01	0.55	<0.01	<0.01	<0.01	<0.01
Snakes and Lizards												
1A	7/13	Lizards	<0.01	0.02	<0.01	0.04	0.03	37.15	<0.01	0.04	0.01	0.06
	10/14	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	7.57	<0.01	<0.01	<0.01	<0.01
2A	7/19	Lizards	<0.01	<0.01	<0.01	0.01	0.01	4.97	<0.01	0.01	<0.01	0.01
	10/12	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	0.19	<0.01	<0.01	<0.01	<0.01
	10/12	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	11.31	<0.01	<0.01	<0.01	<0.01
	10/12	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	1.66	<0.01	<0.01	<0.01	<0.01
3A	7/17	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	2.38	<0.01	0.01	<0.01	0.01
	10/14	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	0.42	<0.01	<0.01	<0.01	<0.01
	10/14	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	7.54	<0.01	<0.01	<0.01	<0.01
	10/14	Rattlesnake	<0.01	<0.01	0.01	<0.01	<0.01	1.89	<0.01	<0.01	<0.01	0.04
7A	7/12	Lizards	<0.01	0.01	0.01	0.01	0.09	12.08	<0.01	0.08	0.02	0.09
	10/15	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	0.16	<0.01	<0.01	0.01	0.23
	10/15	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	18.05	<0.01	<0.01	0.01	0.29
9A[2]	7/13	Lizards	<0.01	0.01	0.01	0.01	0.01	2.71	0.01	0.01	<0.01	<0.01
	10/20	Lizards	<0.01	0.01	0.01	0.01	<0.01	9.70	0.01	<0.01	<0.01	0.21
	12/01	Snake Skin	<0.01	0.01	0.01	0.01	<0.01	0.90	0.01	<0.01	<0.01	0.27
10A	7/18	Lizards	<0.01	0.01	0.01	<0.01	0.04	29.38	<0.01	0.07	0.03	0.02
	10/21	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	5.59	<0.01	<0.01	<0.01	0.40
Insects												
4A	10/21	Hydrophilid Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	0.84	<0.01	<0.01	<0.01	<0.01
5A	7/13	Toebiters	<0.01	<0.01	0.01	0.02	0.19	8.12	0.03	0.02	0.06	0.02
	11/23	Grasshoppers	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
	11/23	Grasshoppers	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01
	10/18	Hydrophilid Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	3.24	<0.01	<0.01	<0.01	<0.01
6A	10/19	Fire Ants	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01
	11/30	Earwigs	<0.01	<0.01	<0.01	<0.01	<0.01	0.17	<0.01	<0.01	<0.01	<0.01
	11/30	Harvester Ants	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
	11/30	Darkling Ground Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.01
8A	12/02	Grasshoppers	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
	12/02	Grasshoppers	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
	10/20	Ground Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	0.77	<0.01	<0.01	<0.01	<0.01
9A	7/13	Grasshoppers	<0.01	0.01	<0.01	0.01	0.01	0.04	<0.01	0.01	<0.01	<0.01
	12/01	Grasshoppers	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01
	12/01	Crickets	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01
	10/20	Red Harvester Ants	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.01
	12/01	Grasshoppers	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
10A	7/18	Fire Ants	0.01	0.01	<0.01	<0.01	0.02	0.75	<0.01	0.01	<0.01	<0.01
	7/13	Crickets	<0.01	<0.01	<0.01	<0.01	0.08	1.93	0.01	0.03	0.07	0.02
	10/21	Field Crickets	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01
	10/21	Black Harvester Ants	<0.01	<0.01	<0.01	<0.01	<0.01	0.18	<0.01	<0.01	<0.01	<0.01
	10/21	Hydrophilid Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	0.12	<0.01	<0.01	<0.01	<0.01
Rabbits												
2A	7/19	Rabbits	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01

(Continued next page)

TABLE 4 (cont'd.). *Pesticide residues in biological samples from Cotton Pest Management Project, Pinal County, Arizona—1971*

Site	Sampling Date	Sample Material	Residues, ppm									
			Ethyl Parathion[1]	β-BHC	Heptachlor Epoxide	Dieldrin	o,p'-DDE	p,p'-DDE	o,p'-TDE	p,p'-TDE	o,p'-DDT	p,p'-DDT
Nonprogram Samples												
Frogs and Toads												
1B	7/13	Toads	<0.01	0.02	0.01	4.68	0.02	27.20	0.02	0.25	0.04	1.12
	10/13	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	3.66	<0.01	<0.01	<0.01	1.15
	10/13	Frogs	<0.01	<0.01	<0.01	<0.01	<0.01	5.35	<0.01	<0.01	<0.01	0.32
2B	10/13	Frogs	<0.01	<0.01	<0.01	<0.01	<0.01	7.93	<0.01	<0.01	<0.01	0.29
	10/13	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	3.83	<0.01	<0.01	<0.01	0.34
3B	7/23	Frogs	<0.01	<0.01	<0.01	<0.01	<0.01	0.87	<0.01	0.01	<0.01	<0.01
	10/14	Frogs	<0.01	<0.01	<0.01	<0.01	<0.01	2.76	<0.01	<0.01	<0.01	0.22
	7/23	Toads	<0.01	<0.01	0.01	0.07	0.03	7.32	0.02	0.17	0.06	0.32
	10/14	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	1.76	<0.01	<0.01	<0.01	0.55
4B	7/20	Frogs	<0.01	<0.01	<0.01	<0.01	0.01	1.60	<0.01	0.09	<0.01	0.13
	10/12	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	1.80	<0.01	<0.01	<0.01	0.28
	10/12	Polliwogs	<0.01	<0.01	<0.01	<0.01	<0.01	24.84	<0.01	<0.01	<0.01	0.99
5B	10/18	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	3.03	<0.01	<0.01	<0.01	0.73
	10/18	Frogs	<0.01	<0.01	<0.01	<0.01	<0.01	8.69	<0.01	<0.01	<0.01	0.27
6B	7/23	Toads	<0.01	0.02	0.03	0.01	0.17	12.02	0.04	1.36	0.09	2.12
	10/19	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	0.73	<0.01	<0.01	<0.01	0.06
	10/19	Frogs	<0.01	<0.01	<0.01	<0.01	<0.01	0.97	<0.01	<0.01	<0.01	0.11
7B	7/22	Toads	<0.01	0.02	0.03	0.18	0.26	19.22	0.16	0.46	0.31	0.65
	10/15	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	2.13	<0.01	<0.01	<0.01	2.13
8B	10/20	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	0.99	<0.01	<0.01	<0.01	0.22
9B	12/01	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	1.79	<0.01	<0.01	<0.01	0.43
	—	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	8.90	<0.01	<0.01	<0.01	1.03
10B	7/14	Toads	<0.01	<0.01	0.01	0.01	0.02	15.67	0.01	0.41	0.01	0.38
	10/21	Toads	<0.01	<0.01	<0.01	<0.01	<0.01	5.71	<0.01	<0.01	<0.01	0.69
	7/14	Frogs	<0.01	<0.01	<0.01	<0.01	0.04	9.72	0.01	0.82	0.02	0.31
Fish												
1B	7/13	Minnows	<0.01	0.04	0.04	<0.01	0.14	4.39	<0.01	0.19	<0.01	0.08
	10/13	Minnows	<0.01	<0.01	<0.01	<0.01	<0.01	9.92	<0.01	<0.01	<0.01	<0.01
3B	7/23	Minnows	<0.01	<0.01	<0.01	<0.01	0.04	0.28	<0.01	0.04	0.01	0.01
	10/14	Minnows	<0.01	<0.01	<0.01	<0.01	<0.01	0.63	<0.01	<0.01	<0.01	<0.01
7B	10/15	Minnows	<0.01	<0.01	<0.01	<0.01	<0.01	18.86	<0.01	<0.01	<0.01	<0.01
8B	7/16	Minnows	<0.01	0.01	0.01	0.01	0.21	8.64	<0.01	0.14	0.01	0.09
	10/20	Minnows	<0.01	<0.01	<0.01	<0.01	<0.01	1.63	<0.01	<0.01	<0.01	<0.01
	10/20	Sunfish	<0.01	<0.01	<0.01	<0.01	<0.01	0.14	<0.01	<0.01	<0.01	<0.01
	10/20	Freshwater Clams	<0.01	<0.01	<0.01	<0.01	<0.01	0.34	<0.01	<0.01	<0.01	<0.01
Birds												
1B	7/13	Mourning Dove (Eggs)	<0.01	0.01	<0.01	<0.01	0.01	0.85	<0.01	0.01	<0.01	0.01
	11/29	Gambel's White Crowned Sparrow	<0.01	<0.01	<0.01	<0.01	<0.01	2.84	<0.01	<0.01	<0.01	<0.01
2B	10/13	Mourning Dove	<0.01	<0.01	<0.01	<0.01	<0.01	1.07	<0.01	<0.01	<0.01	<0.01
	10/13	Sparrow	<0.01	<0.01	<0.01	<0.01	<0.01	0.64	<0.01	<0.01	<0.01	<0.01
3B	10/14	Mallard Duck	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01
5B	7/15	Wren	<0.01	<0.01	<0.01	<0.01	0.01	0.81	<0.01	0.01	<0.01	<0.01
	10/18	Mourning Dove	<0.01	<0.01	<0.01	<0.01	<0.01	0.28	<0.01	<0.01	<0.01	<0.01
	12/14	Fox Sparrow	<0.01	<0.01	<0.01	<0.01	<0.01	0.44	<0.01	<0.01	<0.01	<0.01
6B	10/19	Mourning Doves	<0.01	<0.01	<0.01	<0.01	<0.01	1.33	<0.01	<0.01	<0.01	<0.01
	10/19	Sparrows	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01
	11/30	House Finch	<0.01	<0.01	<0.01	<0.01	<0.01	0.96	<0.01	<0.01	<0.01	<0.01
	11/30	Cassin's Sparrow	<0.01	<0.01	<0.01	<0.01	<0.01	1.17	<0.01	<0.01	<0.01	<0.01
	11/30	Savanna Sparrow	<0.01	<0.01	<0.01	<0.01	<0.01	3.96	<0.01	<0.01	<0.01	<0.01
7B	7/22	Mourning Doves	<0.01	<0.01	<0.01	<0.01	<0.01	0.10	<0.01	0.01	<0.01	0.01
	7/20	Wren	<0.01	0.02	0.01	0.02	0.08	2.22	0.04	0.02	0.04	0.01
	10/15	Mourning Doves	<0.01	<0.01	<0.01	<0.01	<0.01	0.98	<0.01	<0.01	<0.01	<0.01
	10/15	Sparrows	<0.01	<0.01	<0.01	<0.01	<0.01	0.57	<0.01	<0.01	<0.01	<0.01
9B	7/20	Mourning Doves	<0.01	<0.01	<0.01	<0.01	<0.01	0.32	<0.01	<0.01	<0.01	0.01
	7/20	Wren	<0.01	<0.01	<0.01	0.02	<0.01	0.58	<0.01	0.02	<0.01	0.02
	10/21	Mourning Doves	<0.01	<0.01	<0.01	<0.01	<0.01	0.56	<0.01	<0.01	<0.01	<0.01
	10/21	Wren	<0.01	<0.01	<0.01	<0.01	<0.01	0.99	<0.01	<0.01	<0.01	<0.01
	12/01	Mourning Doves	<0.01	<0.01	<0.01	<0.01	<0.01	0.80	<0.01	<0.01	<0.01	<0.01
10B	10/02	Loggerhead Shrike	<0.01	<0.01	<0.01	<0.01	<0.01	76.30	<0.01	<0.01	<0.01	<0.01
Snakes and Lizards												
1B	7/13	Lizards	<0.01	0.01	<0.01	0.01	0.01	12.70	<0.01	0.01	<0.01	0.01
	10/13	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	8.12	<0.01	<0.01	<0.01	<0.01
	10/11	Snake	<0.01	<0.01	<0.01	<0.01	<0.01	44.26	<0.01	<0.01	<0.01	0.88
2B	7/26	Lizards	<0.01	0.02	<0.01	<0.01	0.03	48.92	<0.01	0.03	<0.01	0.06
	10/13	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	18.17	<0.01	<0.01	<0.01	<0.01
	10/13	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	0.86	<0.01	<0.01	<0.01	<0.01
3B	7/23	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	0.12	<0.01	<0.01	<0.01	<0.01
	7/23	Lizards	<0.01	0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
	7/23	Lizards	<0.01	0.01	<0.01	0.01	0.02	9.30	<0.01	0.05	0.01	0.05
	7/23	Lizards	<0.01	0.01	0.01	<0.01	<0.01	3.16	0.01	0.01	0.01	0.01

(Continued next page)

TABLE 4 (cont'd.). *Pesticide residues in biological samples from Cotton Pest Management Project, Pinal Couny, Arizona—1971*

Site	Sampling Date	Sample Material	Residues, ppm									
			Ethyl Parathion[1]	β-BHC	Hepta-chlor Epoxide	Dieldrin	*o,p'*-DDE	*p,p'*-DDE	*o,p'*-TDE	*p,p'*-TDE	*o,p'*-DDT	*p,p'*-DDT
Nonprogram Samples												
	10/14	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	3.56	<0.01	<0.01	<0.01	<0.01
	10/14	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	0.21	<0.01	<0.01	<0.01	<0.01
5B	7/15	Lizards	<0.01	0.47	0.01	0.02	0.07	8.68	<0.01	0.10	0.04	0.03
6B	7/23	Lizards	<0.01	0.01	<0.01	0.04	0.04	57.62	<0.01	0.05	0.01	0.08
7B	7/22	Lizards	<0.01	0.01	0.01	0.01	0.01	6.84	<0.01	0.01	<0.01	0.01
	7/22	Lizards	<0.01	0.01	<0.01	0.01	<0.01	0.11	<0.01	<0.01	<0.01	<0.01
	10/15	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	0.85	<0.01	<0.01	<0.01	0.01
	10/15	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	25.61	<0.01	<0.01	<0.01	1.34
7B	10/15	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	0.94	<0.01	<0.01	<0.01	0.01
9B	7/20	Lizards	<0.01	0.03	0.01	0.04	0.04	16.05	<0.01	0.08	0.02	0.02
10B	7/21	Lizards	<0.01	0.03	0.01	0.01	0.07	20.29	<0.01	0.19	0.01	0.34
	7/14	Lizards	<0.01	0.01	<0.01	<0.01	0.01	10.62	<0.01	<0.01	<0.01	0.02
	10/20	Lizards	<0.01	<0.01	<0.01	<0.01	<0.01	21.21	<0.01	<0.01	<0.01	1.06
Insects												
1B	7/17	Crickets	<0.01	<0.01	<0.01	<0.01	0.05	1.20	0.01	0.02	0.02	0.01
	10/13	Hydrophilid Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	1.22	<0.01	<0.01	<0.01	<0.01
2B	10/13	Ground Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	0.34	<0.01	<0.01	<0.01	<0.01
3B	7/23	Backswimmers	<0.01	0.08	0.07	0.19	0.31	0.58	<0.01	0.04	0.04	0.07
	7/23	Grasshoppers	<0.01	0.01	<0.01	0.02	<0.01	0.82	<0.01	0.01	<0.01	0.01
	7/23	Crickets	<0.01	<0.01	<0.01	<0.01	0.02	0.10	<0.01	0.02	0.01	0.01
	7/16	Harvester Ants	<0.01	0.01	<0.01	0.01	0.01	0.54	0.01	<0.01	<0.01	0.01
4B	7/20	Toebiters	<0.01	0.06	0.01	0.02	0.24	0.88	<0.01	0.02	0.01	<0.01
	—	Toebiters	<0.01	<0.01	<0.01	<0.01	<0.01	0.40	<0.01	<0.01	<0.01	<0.01
	10/12	Grasshoppers	<0.01	<0.01	<0.01	<0.01	<0.01	0.13	<0.01	<0.01	<0.01	<0.01
5B	7/15	Crickets	<0.01	0.02	0.01	0.02	0.02	0.20	0.02	0.02	0.06	0.05
	12/14	Grasshoppers	<0.01	<0.01	0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
6B	7/16	Crickets	<0.01	0.01	0.01	0.20	0.09	1.70	0.03	0.11	0.02	<0.01
7B	7/22	Crickets	<0.01	<0.01	<0.01	<0.01	0.02	0.23	<0.01	0.02	0.02	0.02
	7/22	Grasshoppers	<0.01	<0.01	<0.01	<0.01	0.02	0.23	0.01	0.02	0.02	0.02
	10/15	Toebiters	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01
	10/15	Hydrophilid Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
	10/15	Ground Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01
8B	7/21	Grasshoppers	<0.01	<0.01	<0.01	0.01	0.01	0.23	<0.01	0.01	<0.01	0.01
	10/20	Red Harvester Ants	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01
9B	12/01	Darkling Ground Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	0.16	<0.01	<0.01	<0.01	<0.01
	10/21	Hydrophilid Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01
	10/21	Toebiters	<0.01	<0.01	<0.01	<0.01	<0.01	0.41	<0.01	<0.01	<0.01	<0.01
	10/21	Ground Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	<0.01
	10/21	Grasshopper	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	<0.01
10B	7/21	Grasshoppers	<0.01	0.03	0.01	0.01	0.02	0.02	<0.01	0.01	<0.01	0.02
	7/21	Grasshoppers	<0.01	0.01	<0.01	<0.01	0.01	0.17	0.01	0.02	<0.01	0.02
	10/02	Bandwing Grasshoppers	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
	10/21	Hydrophilid Beetles	<0.01	<0.01	<0.01	<0.01	<0.01	1.12	<0.01	<0.01	<0.01	<0.01
	10/21	Backswimmers	<0.01	<0.01	<0.01	<0.01	<0.01	6.24	<0.01	<0.01	<0.01	<0.01
Rabbits and Rats												
1B	11/29	Cotton Rat	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01
9B	7/20	Rabbit	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
10B	7/21	Rabbit	0.03	<0.01	<0.01	<0.01	0.01	0.18	<0.01	0.01	<0.01	<0.01

NOTE: Data corrected for pesticide recovery from fortified samples.
Lower limits of sensitivity = 0.01 ppm, except for toxaphene, which was 0.05 ppm.

[1] Methyl parathion, malathion, methyl trithion, and ethion residues did not exceed the lower limits of detectability of 0.01 ppm.

[2] γ-BHC = 0.01 ppm.

BRIEF

DDT Residues in Air in the Mississippi Delta, 1975[1]

Robert D. Arthur, Jimmie D. Cain, and Ben F. Barrentine[2]

ABSTRACT

In a previous publication the authors reported an 88 percent decrease in ΣDDT (DDT plus metabolities) in air between 1972 and 1974 in the Mississippi Delta. This period was the first two years after the use of DDT was banned in the United States. The present report shows an additional 36 percent decrease in ΣDDT levels in air between 1974 and 1975. Thus in the past three years ΣDDT in air has decreased by 92 percent, a much more rapid decrease than had been expected.

Introduction

For the past several years, pesticide levels in air in the Mississippi Delta have been measured to determine seasonal and yearly trends. Arthur et al. (*1*) reported pesticide levels in the Delta for 1972-74. The authors observed an 84 percent decrease in Σ DDT (DDT plus metabolites) residues between 1972 and 1973, the first year after the ban on DDT use in the United States. A 26 percent decrease in Σ DDT in air was reported between 1973 and 1974.

Sampling and Analysis

Air samples were taken weekly in Stoneville, Miss., located in the middle of the most intensive cotton-growing area of the State. A Misco Model 88 air pesticide sampler was used with ethylene glycol as the trapping agent. A timer was set so that the sampler would operate 4.29 minutes every hour for seven days, making a total collecting time of 12 hours a week. Approximately 7m^3 air was sampled each week.

Analytical procedures and instrument parameters were described previously (*1*).

Results and Discussion

Monthly arithmetic and geometric means of Σ DDT in air from 1972 through 1975 are presented in Table 1. The arithmetic mean in 1975 was 7.6 ng/m^3 compared to 11.9 ng/m^3 in 1974, and the geometric mean in 1975 was 5.1 ng/m^3 compared to 8.1 ng/m^3 in 1974. This represents a 36 percent decrease in the arithmetic mean of DDT and a 37 percent decrease in the geometric mean of Σ DDT during the year. Since January 1, 1973, the date on which DDT was banned, arithmetic and geometric means of ΣDDT in air have decreased 92 percent and 85 percent, respectively.

So far some DDT has been found each month in the air from the Delta. The lowest monthly value was 1.3 ng/m^3 in December 1975. Since ΣDDT has decreased so rapidly, it is extremely important to continue monitoring air in the Mississippi Delta in order to determine at what point DDT will no longer be detected.

In light of these findings, and as more data on the disappearance of DDT from the environment are obtained, authors believe that certain reported characteristics of DDT should be re-evaluated, particularly its extreme stability and/or lack of biodegradability in the environment.

[1] Paper No. 3296, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, Miss. Study financed by U.S. Environmental Protection Agency Contract 68-02-0699, Epidemiologic Studies Program, Technical Services Division, Office of Pesticide Programs.

[2] Department of Biochemistry, Mississippi State University, Mississippi State, Miss. 39762. Reprints available from this address.

LITERATURE CITED

(*1*) *Arthur, R. D., J. D. Cain, and B. F. Barrentine. 1976.* Atmospheric levels of pesticides in the Mississippi Delta. Bull. Environ. Contam. Toxicol. 15(2):129-134.

APPENDIX

Chemical Names of Compounds Discussed in This Issue[1]

ABATE	See temefos.
ALDRIN	Not less than 95% of 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo*-*exo*-5,8-dimethanonaphthalene
AROCLOR	A mixture of chlorinated terphenyls
BHC (BENZENE HEXACHLORIDE)	1,2,3,4,5,6-Hexachlorocyclohexane (mixture of isomers). Commercial product contains several isomers of which *gamma* is most active as an insecticide.
CARBARYL	1-Naphthyl N-methylcarbamate
CHLORDANE	1,2,3,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene. The technical product is a mixture of several compounds including heptachlor, chlordene, and two isomeric forms of chlordane.
DDD	See TDE.
DDE	Dichlorodiphenyl dichloro-ethylene (degradation product of DDT) *p,p'*-DDE: 1,1-Dichloro-2,2-bis(*p*-chlorophenyl) ethylene *o,p'*-DDE: 1,1-Dichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl)ethylene
DDT	Main component (*p,p'*-DDT): α-Bis(*p*-chlorophenyl) β,β,β-trichloroethane. Other isomers are possible and some are present in the commercial product. *o,p'*-DDT: [1,1,1-Trichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl) ethane]
DIELDRIN	Not less than 85% of 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo*-*exo*-5,8-dimethanonaphthalene
DIMETHOATE	O,O-Dimethyl S-(N-methylcarbamoylmethyl) phosphorodithioate
ENDRIN	1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo*-*endo*-5,8-dimethanonaphthalene
ETHION	O,O,O',O'-Tetraethyl S,S'-methylene bisphosphorodithioate
FENTHION	*O,O*-Dimethyl *O*-[3-methyl-4-(methylthio) phenyl]phosphorothioate
HEPTACHLOR	1,4,5,6,7,8,8-Heptachlor-3a,4,7,7a-tetrahydro-4,7-*endo*-methanoindene
HEPTACHLOR EPOXIDE	1,4,5,6,7,8,8-Heptachloro 2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-methanoindane
LINDANE	Gamma isomer of benzene hexachloride (1,2,3,4,5,6-hexachlorocyclohexane) of 99+% purity
MALATHION	S-[1,2-Bis(ethoxycarbonyl)ethyl] O,O-dimethyl phosphorodithioate
MIREX	Dodecachlorooctahydro-1,3,4-metheno-2H-cyclobuta[cd]pentalene
NONACHLOR	1,2,3,4,5,6,7,8,8-Nonachloro-3a,4,7,7a-tetrahydro-4,7-methanoindan
OXYCHLORDANE	2,3,4,5,6,6a,7,7-Octachloro-1a,1b,5,5a,6,6a-hexahydro-2,5-methano-2H-indeno(1,2-β)oxirene
PARATHION	O,O-Diethyl O-*p*-nitrophenyl phosphorothioate
PCB'S (POLYCHLORINATED BIPHENYLS)	Mixtures of chlorinated biphenyl compounds having various percentages of chlorine
SEVIN	See carbaryl.
STROBANE	Polychlorinates of camphene, pinene, and related terpenes
2,4,5-T	(2,4,5-Trichlorophenoxy) acetic acid
TDE	2,2-Bis(*p*-chlorophenyl)-1,1-dichloroethane
TOXAPHENE	Chlorinated camphene (67-69% chlorine). Product is a mixture of polychlor bicyclic terpenes with chlorinated camphenes predominating.
TRITHION	*S*-((*p*-Chlorophenylthio)methyl)*O,O*-diethyl phosphorodithioate

[1] Does not include chemicals listed only in tables of paper by Manske/Johnson.

Acknowledgment

The Editorial Advisory Board wishes to thank the following persons for their valuable assistance in reviewing papers submitted for publication in Volume 10 of the *Pesticides Monitoring Journal:*

U.S. DEPARTMENT OF AGRICULTURE
Daniel R. Embody
George F. Fries
Kenneth R. Hill
Philip C. Kearney
Edwin A. Woolson

U.S. ENVIRONMENTAL PROTECTION AGENCY
Philip A. Butler
Frederick W. Kutz

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Paul E. Corneliussen
Sidney Williams
George Yip
Anne R. Yobs

U.S. DEPARTMENT OF INTERIOR
Donald F. Goerlitz

Information for Contributors

The *Pesticides Monitoring Journal* welcomes from all sources qualified data and interpretative information on pesticide monitoring. The publication is distributed principally to scientists, technicians, and administrators associated with pesticide monitoring, research, and other programs concerned with pesticides in the environment. Other subscribers work in agriculture, chemical manufacturing, food processing, medicine, public health, and conservation.

Articles are grouped under seven headings. Five follow the basic environmental components of the National Pesticide Monitoring Program: Pesticide Residues in People; Pesticide Residues in Water; Pesticide Residues in Soil; Pesticide Residues in Food and Feed; and Pesticide Residues in Fish, Wildlife, and Estuaries. The sixth is a general heading; the seventh encompasses briefs.

Monitoring is defined here as the repeated sampling and analysis of environmental components to obtain reliable estimates of levels of pesticide residues and related compounds in these components and the changes in these levels with time. It can include the recording of residues at a given time and place, or the comparison of residues in different geographic areas. The Journal will publish results of such investigations and data on levels of pesticide residues in all portions of the environment in sufficient detail to permit interpretations and conclusions by author and reader alike. Such investigations should be specifically designed and planned for monitoring purposes. The Journal does not generally publish original research investigations on subjects such as pesticide analytical methods, pesticide metabolism, or field trials (studies in which pesticides are experimentally applied to a plot or field and pesticide residue depletion rates and movement within the treated plot or field are observed).

Authors are responsible for the accuracy and validity of their data and interpretations, including tables, charts, and references. Pesticides ordinarily should be identified by common or generic names approved by national or international scientific societies. Trade names are acceptable for compounds which have no common names. Structural chemical formulas should be used when appropriate. Accuracy, reliability, and limitations of sampling and analytical methods employed must be described thoroughly, indicating procedures and controls used, such as recovery experiments at appropriate levels, confirmatory tests, and application of internal standards and interlaboratory checks. The procedure employed should be described in detail. If reference is made to procedures in another paper, crucial points or modifications should be noted. Sensitivity of the method and limits of detection should be given, particularly when very low levels of pesticide residues are being reported. Specific note should be made regarding correction of data for percent recoveries. Numerical data, plot dimensions, and instrument measurements should be reported in metric units.

PREPARATION OF MANUSCRIPTS

——Prepare manuscripts in accord with the *CBE Style Manual*, third edition, Council of Biological Editors, Committee on Form and Style, American Institute of Biological Sciences, Washington, D.C., and/or the *U.S. Government Printing Office Style Manual*. For further enrichment in language and style, consult Strunk and White's *Elements of Style*, second edition, MacMillan Publishing Co., New York, N.Y., and *A Manual of Style*, twelfth edition, University of Chicago Press, Chicago, Ill.

——On the title page include authors' full names with affiliations and addresses footnoted; the senior author's name should appear first. Authors are those individuals who have actually written or made essential contributions to the manuscript and bear ultimate responsibility for its content. Use the Acknowledgment section at the end of the paper for crediting secondary contributors.

——Preface each manuscript with an informative abstract not to exceed 200 words. Construct this piece as an entity separate from the paper itself; it is potential material for domestic and foreign secondary publications concerned with the topic of study. Choose language that is succinct but not detailed, summarizing reasons for and results of the study, and mentioning significant trends. Bear in mind the literature searcher and his/her need for key words in scanning abstracts.

——Forward original manuscript and three copies by first-class mail in flat form: do not fold or roll.

——Type manuscripts on 8½-by-11-inch paper with generous margins on all sides, and end each page with a completed paragraph. Recycled paper is acceptable if it does not degrade the quality of reproduction. Double-space all copy, including tables and references, and number each page.

——Place tables, charts, and illustrations, properly titled, at the end of the article with notations in the text to show where they should be inserted. *Treat original artwork as irreplaceable material.* Lightly print author's name and illustration number with a ballpoint pen on the back of each figure. Wrap in cardboard to prevent mutilation; do not use paperclips or staples.

——Letter charts distinctly so that numbers and words will be legible when reduced. Execute drawings in

black ink on plain white paper. Submit original drawings or sharp glossy photographs: no copies will be accepted.

——Number literature citations in alphabetical order according to author. For journal article include, respectively, author, year, title, journal name as abbreviated in *Chemical Abstracts Service Source Index*, and volume, issue, and page numbers. For book references cite, respectively, author, year, chapter title, pages, and editor if pertinent, book title, and name and city of publisher. For Government manuals list originating agency and relevant subgroup, year, chapter title and editor if pertinent, manual title, and relevant volume, chapter, and/or page numbers. Do not list private communications among Literature Cited. Insert them parenthetically within the text, including author, date, and professional or university affiliation indicating author's area of expertise.

The Journal welcomes brief papers reporting monitoring data of a preliminary nature or studies of limited scope. A section entitled Briefs will be included as necessary to provide space for short papers which present timely and informative data. These papers must be limited to two published pages (850 words) and should conform to the format for regular papers accepted by the Journal.

Manuscripts require approval by the Editorial Advisory Board. When approved, the paper will be edited for clarity and style. Editors will make the minimum changes required to meet the needs of the general Journal audience, including international subscribers for whom English is a second language. Authors of accepted manuscripts will receive edited typescripts for approval before type is set. After publication, senior authors will receive 100 reprints.

Manuscripts are received and reviewed with the understanding that they have not been accepted previously for publication elsewhere. If a paper has been given or is intended for presentation at a meeting, or if a significant portion of its contents has been published or submitted for publication elsewhere, notations of such should be provided. Upon acceptance, the original manuscript and artwork become the property of the *Pesticides Monitoring Journal.*

Every volume of the Journal is available on microfilm. Requests for microfilm and correspondence on editorial matters should be addressed to:

Paul Fuschini (WH-569)
Editorial Manager
Pesticides Monitoring Journal
U.S. Environmental Protection Agency
Washington, D.C. 20460

For questions concerning GPO subscriptions and back issues write:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

☆ U.S. GOVERNMENT PRINTING OFFICE: 1977—720-236/3

SUBJECT AND AUTHOR INDEXES

Volume 10, June 1976—March 1977

Preface

Primary headings in the subject index include pesticide compounds, media in which pesticide residues are monitored, and major concepts related to the monitoring of pesticides in the environment. Pesticide compounds are listed by common names; trade names are used for those which have no common names.

Secondary headings cross-reference the primary headings. For a paper which discusses five or more organochlorines the compounds are grouped by class under media and concept headings but each compound appears individually under the primary headings for pesticide compounds.

In the author index all information on a paper appears in the senior author's citations: associate authors, title of the paper, and volume, issue, and pages where the article was published. Names of associate authors are cross-referenced as minor headings, but the reader is referred to the senior author's entry for the paper's complete citation.

SUBJECT INDEX

A

Abate, see Temefos

Air
DDT
10(4):168

Aldrin
Factors Influencing Residues
10(3):101-110
Food and Feed
10(2):41-43
10(4):134-148
Humans
10(4):130-133
Sediment
10(1):24-29
10(2):61-67
10(3):101-110
Soil
10(3):101-110
Water
10(1):24-29
10(2):61-67
10(3):101-110
Wildlife
10(1):24-29
10(2):61-67
10(3):101-110

Aroclor
Factors Influencing Residues
10(3):84-86
Wildlife
10(3):79-83
10(3):84-86

Arsenic
Factors Influencing Residues
10(2):54-60
Food and Feed
10(4):C
Soil
10(2):54-60

Azinphosethyl
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

Azinphosmethyl
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

B

BHC/Lindane
Factors Influencing Residues
10(1):10-17
10(3):101-110
Food and Feed
10(1):18-23
10(2):35-40
10(2):41-43
10(4):134-138
Humans
10(4):121-129
10(4):130-133
Sediment
10(1):24-29
10(2):61-67
10(3):101-110
Soil
10(3):101-110
Water
10(1):24-29
10(2):61-67
10(3):101-110
Wildlife
10(1):19-17
10(1):24-29
10(2):61-67
10(3):101-110

Botran
Food
10(4):134-148

C

Cadmium
Food
10(4):134-148

Captan
Food
10(4):134-148

Carbaryl
Food
10(4):134-148

Carbophenothion
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

Chlordane
Factors Influencing Residues
10(2):54-60
10(3):101-110
Food and Feed
10(2):41-43
10(4):134-148
Sediment
10(1):24-29
10(2):61-67
10(3):101-110
Soil
10(2):54-60
10(3):101-110
10(3):114-116
Water
10(1):24-29
10(2):61-67
10(3):101-110
Wildlife
10(1):24-29
10(2):61-67
10(3):101-110

CIPC
Food and Feed
10(4):134-148

Crufomate
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

D

2,4-D
Food and Feed
10(3):111-113
Soil
10(3):111-113

Dacthal®
Food and Feed
10(4):134-148

DCPA
Food
10(4):134-148

DDD, see TDE

DDE
Factors Influencing Residues
10(1):2-3
10(1):10-17
10(2):44-53
10(2):54-60
10(3):84-86
10(3):87-91
10(3):101-110
Food and Feed
10(1):18-23
10(2):41-43
10(3):114-116
10(4):134-148
Humans
10(4):121-129
10(4):130-133
Sediment
10(1):24-29
10(2):61-67
10(3):87-91
10(3):101-110

Soil
10(2):54-60
10(3):101-110
10(3):114-116
Water
10(1):24-29
10(2):61-67
Wildlife
10(1):2-3
10(1):10-17
10(1):24-29
10(2):44-53
10(2):61-67
10(3):79-83
10(3):84-86
10(3):92-95
10(3):96-100
10(4):149-158

DDT
Air
10(4):168
Factors Influencing Residues
10(1):2-3
10(1):10-17
10(2):44-53
10(2):54-60
10(2):61-67
10(3):84-86
10(3):87-91
10(3):96-100
10(3):101-110
10(4):168
Food and Feed
10(1):18-23
10(2):41-43
10(3):114-116
10(4):134-148
Humans
10(4):121-129
10(4):130-133
Sediment
10(1):24-29
10(2):61-67
10(3):87-91
10(3):101-110
Soil
10(2):54-60
10(3):101-110
10(3):114-116
Water
10(1):24-29
10(2):61-67
10(3):101-110
Wildlife
10(1):2-3
10(1):10-17
10(1):24-29
10(2):44-53
10(2):61-67
10(3):79-83
10(3):84-86
10(3):92-95
10(3):96-100
10(3):101-110
10(4):149-158

DDTR
Factors Influencing Residues
10(2):54-60
Food and Feed
10(2):35-40
10(3):114-116
Soil
10(2):54-60
10(3):114-116

DEF
Food and Feed
10(2):41-43

Degradation
Quintozene
10(2):68-73

Diazinon
Food and Feed
10(2):41-43
10(3):114-116
10(4):134-148
Sediment
10(2):61-67
10(3):87-91
Water
10(2):61-67
10(3):87-91
Wildlife
10(2):61-67

Dicofol
Food and Feed
10(1):18-23
10(4):134-148

Dieldrin
Factors Influencing Residues
10(1):10-17
10(2):44-53
10(2):54-60
10(3):84-86
10(3):87-91
10(3):101-110
Food and Feed
10(2):35-40
10(2):41-43
10(4):134-148
Humans
10(4):121-129
10(4):130-133
Sediment
10(1):24-29
10(2):61-67
10(3):87-91
10(3):101-110
Soil
10(2):54-60
10(3):101-110
10(3):114-116
Water
10(1):24-29
10(2):61-67
10(3):101-110
Wildlife
10(1):10-17
10(1):24-29
10(2):44-53
10(2):61-67
10(3):79-83
10(3):84-86
10(3):92-95
10(3):101-110
10(4):149-158

Dimethoate
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

Disulfoton
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

E

Endosulfan
Food
10(4):134-148
Sediment
10(2):61-67
10(3):87-91
Water
10(2):61-67
Wildlife
10(2):61-67

Endrin
Factors Influencing Residues
10(2):54-60
10(3):84-86
10(3):101-110
Food and Feed
10(2):35-40
10(2):41-43
Humans
10(4):130-133
Sediment
10(2):61-67
10(3):101-110
Soil
10(2):54-60
10(3):101-110
Water
10(2):61-67
10(3):101-110

Wildlife
10(2):61-67
10(3):84-86
10(3):101-110

Ethion
Food and Feed
10(2):41-43
10(4):134-148
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

Ethyl Parathion
Food and Feed
10(2):41-43

F

Factors Influencing Residues
Age
DDT
10(3):96-100
organochlorines
10(2):44-53
10(3):101-110
Environmental, Geographical, and Locational
arsenic
10(2):54-60
DDE
10(3):87-91
DDT
10(2):61-67
10(3):87-91
dieldrin
10(3):87-91
organochlorines
10(1):10-17
10(2):44-53
10(2):54-60
10(3):84-86
PCB's
10(2):61-67
TDE
10(3):87-91
Farming Practices and Land Use
organochlorines
10(2):54-60
10(3):101-110
quintozene
10(2):68-73
Physical Characteristics of Pesticide
temefos
10(1):4-6
Seasonal and Temporal
DDT
10(4):168
mercury
10(1):7-9
organochlorines
10(1):10-17
10(2):44-53
temefos
10(1):4-6
Sex
organochlorines
10(2):44-53
Species
DDE
10(1):2-3
DDT
10(1):2-3
mercury
10(1):7-9
organochlorines
10(2):44-53
10(3):101-110
Trophic Level
DDT
10(3):96-100
mercury
10(1):7-9
Weight
DDT
10(3):96-100

Fenitrothion
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

Food and Feed
Fodder
DDE
10(3):114-116
DDT
10(3):114-116
DDTR
10(3):114-116
diazinon
10(3):114-116
organophosphates
10(2):41-43
TDE
10(3):114-116
Total Diet
arsenic
10(4):134-148
malathion
10(1):18-23
metals
10(4):134-148
organochlorines
10(1):18-23
10(4):134-148
organophosphates
10(4):134-148
Vegetables and Grains
BHC/lindane
10(2):35-40
2,4-D
10(3):111-113
DDTR
10(2):35-40
dieldrin
10(2):35-40
endrin
10(2):35-40
HCB
10(2):68-73
mercury
10(3):111-113
PCA
10(2):68-73
PCTA
10(2):68-73
QCB
10(2):68-73
quintozene
10(2):68-73

H

HCB
Factors Influencing Residues
10(1):10-17
Food and Feed
10(2):68-73
10(4):134-148
Humans
10(4):121-129
Soil
10(2):68-73
Wildlife
10(1):10-17

Heptachlor
Factors Influencing Residues
10(2):54-60
Food and Feed
10(2):41-43
10(4):134-148
Humans
10(4):130-133
Sediment
10(2):61-67
Soil
10(2):54-60
Water
10(1):24-29
10(2):61-67
Wildlife
10(1):24-29
10(2):61-67

Heptachlor Epoxide
Factors Influencing Residues
10(1):10-17
10(2):54-60
10(3):101-110
Food and Feed
10(2):41-43
10(4):134-148
Humans
10(4):121-129
10(4):130-133
Sediment
10(2):61-67
10(3):101-110
Soil
10(2):54-60
10(3):101-110
10(3):114-116
Water
10(1):24-29
10(2):61-67
10(3):101-110
Wildlife
10(1):10-17
10(2):61-67
10(3):101-110

Humans
Blood
organochlorines
10(4):121-129
Milk
organochlorines
10(4):121-129
10(4):130-133

I

Imidan
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

K

Kelthane®, see Dicofol

L

Lead
Food
10(4):134-148

Leptophos
Food
10(4):134-148

M

Malathion
Food and Feed
10(1):18-23
10(2):41-43
10(4):134-148
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

Mercury
Factors Influencing Residues
10(1):7-9
Food and Feed
10(3):111-113
10(4):134-148
Soil
10(3):111-113
Wildlife
10(1):7-9

Methoxychlor
Food
10(4):134-148
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

Methyl Parathion
Food and Feed
10(2):41-43
10(4):134-148
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

Methyl Trithion
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

Mirex
Humans
10(4):130-133

N

Nitrofen
Food and Feed
10(4):134-148

Nonachlor
Humans
10(4):130-133

O

Orthophenylphenol
Food
10(4):134-148

Oxychlordane
Factors Influencing Residues
10(1):10-17
10(2):44-53
Humans
10(4):130-133
Wildlife
10(1):10-17
10(2):44-53

P

Parathion
Food
10(4):134-148
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

PCA
Food
10(2):68-73
10(4):134-148
Soil
10(2):68-73

PCB's (see also Aroclor)
Humans
10(4):121-129
10(4):130-133
Factors Influencing Residues
10(1):10-17
10(2):44-53
10(2):61-67
Food and Feed
10(2):41-43
10(4):134-148
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(1):10-17
10(2):44-53
10(2):61-67
10(3):92-95
10(4):149-158

PCNB, see Quintozene

PCP
Food
10(4):134-148

PCTA
Food
10(2):68-73
Soil
10(2):68-73

Pentachloroaniline, see PCA

Pentachlorobenzene, see QCB

Pentachlorothioanisole, see PCTA

Perthane®
Food
10(4):134-148

Phorate
Food and Feed
10(2):41-43
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

Phosalone
Food
10(4):134-148

Phosphamidon
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

Q

QCB
Food
10(2):68-73
Soil
10(2):68-73

Quintozene
Degradation
10(2):68-73
Factors Influencing Residues
10(2):68-73
Food and Feed
10(2):68-73
10(4):134-148
Soil
10(2):68-73

R

Ronnel
Food
10(4):134-148
Sediment
10(2):61-67
Water
10(2):61-67
Wildlife
10(2):61-67

S

Sediment
Lakes and Ponds
organochlorines
10(2):61-67
10(4):159-167
organophosphates
10(2):61-67
10(4):159-167

Rivers and Streams
diazinon
10(3):87-91
organochlorines
10(1):24-29
10(3):87-91
10(3):101-110

Selenium
Food
10(4):134-148

Soil
Croplands
2,4-D
10(3):111-113
HCB
10(2):68-73
mercury
10(3):111-113
organochlorines
10(3):101-110
10(3):114-116
10(4):159-167
organophosphates
10(4):159-167
PCA
10(2):68-73
PCTA
10(2):68-73
QCB
10(2):68-73
quintozene
10(2):68-73
Forests
organochlorines
10(3):101-110
Residential Areas
organochlorines
10(3):101-110
Urban
arsenic
10(2):54-60
organochlorines
10(2):54-60
Soil
10(2):54-60
10(3):101-110
10(3):114-116
Water
10(1):24-29
10(2):61-67
Wildlife
10(1):10-17
10(1):24-29
10(2):44-53
10(2):61-67
10(3):79-83
10(3):92-95
10(3):96-100
10(4):149-158

Tedion, see Tetradifon

Temefos
Factors Influencing Residues
10(1):4-6
Wildlife
10(1):4-6

Tetradifon
Food and Feed
10(1):18-23

Toxaphene
Factors Influencing Residues
10(2):54-60
Food and Feed
10(2):41-43
10(4):134-148
Soil
10(2):54-60

Trifluralin
Food and Feed
10(2):41-43

Trithion
Food and Feed
10(2):41-43

T

TCNB
Food
10(4):134-148

TDE
Factors Influencing Residues
10(1):10-17
10(2):44-53
10(2):54-60
10(3):87-91
10(3):101-110
Food and Feed
10(2):41-43
10(3):114-116
10(4):134-148
Humans
10(4):121-129
10(4):130-133
Sediment
10(1):24-29
10(2):61-67
10(3):87-91
10(3):101-110

W

Water (see also Sediment)
Canals and Ditches
organochlorines
10(4):159-167
organophosphates
10(4):159-167
Lakes and Ponds
organochlorines
10(2):61-67
10(4):159-167
organophosphates
10(2):61-67
10(4):159-167
Rivers and Streams
diazinon
10(3):87-91
organochlorines
10(1):24-29
10(3):101-110

Wildlife
Amphibians
organochlorines
10(4):159-167
organophosphates
10(4):159-167
Aquatic
organochlorines
10(3):101-110
Birds
mercury
10(1):7-9
organochlorines
10(1):10-17
10(3):84-86
10(4):149-158
10(4):159-167
organophosphates
10(4):159-167
Ducks
DDE
10(1):2-3
DDT
10(1):2-3
mercury
10(1):7-9
organochlorines
10(4):159-167
organophosphates
10(4):159-167
Fish
DDE
10(3):96-100
DDT
10(3):96-100
organochlorines
10(3):92-95
10(3):101-110
10(4):149-158
10(4):159-167
organophosphates
10(4):159-167
TDE
10(3):96-100
Invertebrates
organochlorines
10(4):159-167
organophosphates
10(4):159-167
Mammals
organochlorines
10(2):44-53
10(3):79-83
Plankton
DDE
10(3):96-100
DDT
10(3):96-100
organochlorines
10(2):61-67
organophosphates
10(2):61-67
TDE
10(3):96-100
Reptiles
organochlorines
10(4):159-167
organophosphates
10(4):159-167
Shellfish
organochlorines
10(1):24-29
10(4):149-158
temefos
10(1):4-6

Z

Zinc
Food
10(4):134-148

AUTHOR INDEX

A

ARTHUR, ROBERT D., CAIN, JIMMIE D., and BARRENTINE, BEN F. DDT residues in air in the Mississippi Delta, 1975. 10(4):168

B

BARRENTINE, BEN F., see ARTHUR, ROBERT D.
BELISLE, ANDRE A., see KLAAS, ERWIN E.
BOND, CHARLES A., see WOODHAM, DONALD W.

C

CAIN, JIMMIE D., see ARTHUR, ROBERT D.
CAREY, ANN E., WIERSMA, G. BRUCE, and TAI, HAN. Pesticide residues in urban soils from 14 United States cities, 1970. 10(2):54–60
CARRASCO, J. M., CUNAT, P., MARTINEZ, M., and PRIMO, E. Pesticide residues in total diet samples, Spain—1971–72. 10(1):18–23
CHUN, MICHAEL, see TANITA, RUSSELL.
CLARK, DONALD R., JR., and PROUTY, RICHARD M. Organochlorine residues in three bat species from four localities in Maryland and West Virginia, 1973. 10(2):44–53
CUCOS, SIMI, see POLISHUK, Z. W.
CUNAT, P., see CARRASCO, J. M.

D

DEJONCKHEERE, W., STEURBAUT, W. and KIPS, R. H. Residues of quintozene, its contaminants and metabolities in soil, lettuce, and witloof-chicory, Belgium—1969–74. 10(2):68–73

E

ELDER, JAMES B., see STENDELL, REY C.

F

FITZPATRICK, GEORGE, and SUTHERLAND, DONALD J. Uptake of the mosquito larvicide temefos by the salt marsh snail, New Jersey—1973–74. 10(1):4–6

G

GLOOSCHENKO, W. A., STRACHAN, W. M. J., and SAMPSON, R. C. J. Distribution of pesticides and polychlorinated biphenyls in water, sediments, and seston of the Upper Great Lakes—1974. 10(2):61–67
GOWEN, J. A., WIERSMA, G. B. and TAI, H. Mercury and 2,4-D levels in wheat and soils from sixteen States, 1969. 10(3):111–113
GOWEN, J. A., WIERSMA, G. B., TAI, H., and MITCHELL, W. G. Pesticide levels in hay and soils from nine States, 1971. 10(3):114–116

H

HICKEY, JOSEPH J., see NEIDERMYER, WILLIAM J.

J

JOHNSON, JERRY M., see TANITA, RUSSELL.
JOHNSON, R. D., see MANSKE, D. D.

K

KIM, KE CHUNG, see KURTZ, DAVID A.
KIPS, R. H., see DEJONCKHEERE, W.
KLAAS, ERWIN E., and BELISLE, ANDRE A. Organochlorine pesticide and polychlorinated biphenyl residues in selected fauna from a New Jersey salt marsh—1967 vs. 1973. 10(4):149-158
KLAAS, ERWIN E., see STENDELL, REY C.
KURTZ, DAVID A., and KIM, KE CHUNG. Chlorinated hydrocarbon and PCB residues in tissues and lice of northern fur seals, 1972. 10(3):79–83
KUTZ, FREDERICK W., see STRASSMAN, SANDRA C.

L

LEMESCH, C., see POLISHUK, Z. W.

M

MACIOLEK, JOHN, see TANITA, RUSSELL.
MANSKE, D. D., and JOHNSON, R. D. Pesticide and other chemical residues in total diet samples (X). 10(4):134-148
MARION, WAYNE R. Organochlorine pesticide residues in plain chachalacas from south Texas, 1971–72. 10(3):84–86
MARTINEZ, M., see CARRASCO, J. M.
MILES, J. R. W. Insecticide residues on stream sediments in Ontario, Canada. 10(3):87–91
MITCHELL, W. G., see GOWEN, J. A.
MITCHELL, W. G., see YANG, H. S. C.

N

NEIDERMYER, WILLIAM J., and HICKEY, JOSEPH J. Chronology of organochlorine compounds in Lake Michigan fish, 1929–66. 10(3):92–95

O

OHLENDORF, HARRY M., see STENDELL, REY C.

P

PAZ, JACOB D. Preliminary study of the occurrence and distribution of DDT residues in the Jordan watershed, 1971. 10(3):96–100
POLISHUK, Z. W., RON, M., WASSERMANN, M., CUCOS, SIMI, WASSERMANN, DORA, and LEMESCH, C. Organochlorine compounds in human blood plasma and milk. 10(4):121-129
PRIMO, E., see CARRASCO, J. M.
PROUTY, RICHARD M., see CLARK, DONALD R.

R

REED, LLOYD A., see TRUHLAR, JOHN F.
REEVES, ROBERT G., see WOODHAM, DONALD W.
RICHARDSON, HARRY, see WOODHAM, DONALD W.
ROBINSON, HUGH F., see WOODHAM, DONALD W.
RON, M., see POLISHUK, Z. W.

S

SAMPSON, R. C. J., see GLOOSCHENKO, W. A.
STENDELL, REY C., OHLENDORF, HARRY M., KLAAS, ERWIN E., and ELDER, JAMES B. Mercury in eggs of aquatic birds, Lake St. Clair—1973. 10(1):7–9
STEURBAUT, W., see DEJONCKHEERE, W.
STRACHAN, W. M. J., see GLOOSCHENKO, W. A.
STRASSMAN, SANDRA C., and KUTZ, FREDERICK W. Insecticide residues in human milk from Arkansas and Mississippi. 10(4):130-133
SUTHERLAND, DONALD J., see FITZPATRICK, GEORGE.
SUZUKI, M., YAMATO, Y., and WATANABE, T. Organochlorine insecticide residues in vegetables of the Kitakyushu District, Japan—1971–74. 10(2):35–40

T

TAI, H., see CAREY, ANN E.
TAI, H., see GOWEN J. A.
TANITA, RUSSELL, JOHNSON, JERRY M., CHUN, MICHAEL, and MACIOLEK, JOHN. Organochlorine pesticides in the Hawaii Kai Marina, 1970–74. 10(1):24–29
TRUHLAR, JOHN F., and REED, LLOYD A. Occurrence of pesticide residues in four streams draining different land-use areas in Pennsylvania, 1969–71. 10(2):101–110

W

WASSERMANN, DORA, see POLISHUK, Z. W.
WASSERMANN, M., see POLISHUK, Z. W.

WATANABE, T., see SUZUKI, M.
WHITE, DONALD H. Nationwide residues of organochlorines in starlings, 1974. 10(1):10–17
WHITE, DONALD H. Residues of DDT and DDE in livers of waterfowl, northeastern Louisiana—1970–71. 10(1):2–3
WIERSMA, G. B., see CAREY, ANN E.
WIERSMA, G. B., see GOWEN, J. A.
WIERSMA, G. B., see YANG, H. S. C.
WOODHAM, DONALD W., ROBINSON, HUGH F., REEVES, ROBERT G., BOND, CHARLES A., and RICHARDSON, HARRY. Monitoring agricultural insecticides in the cooperative cotton pest management program in Arizona, 1971—first-year study. 10(4):159-167

Y

YAMATO, Y., see SUZUKI, M.
YANG, H. S. C., WIERSMA, G. B., and MITCHELL, W. G. Organochlorine pesticide residues in sugarbeet pulps and molasses from 16 States, 1971. 10(2):41–43

The Administrator of the U.S. Environmental Protection Agency has determined that the publication of this periodical is necessary in the transaction of public business required by law of this Agency. Use of funds for printing this publication approved by the Director of the Office of Management and Budget, May 19, 1976.

ORDER BLANK
FOR PMJ

To: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

Please enter my Subscription for Pesticides Monitoring Journal. I am enclosing Money Order ☐ Check ☐ for this subscription. ($7.90 a year; $2.00 additional for foreign mailing)

*Please address the PMJ as follows:*_____

_____

_____

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C. 1967

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402. Subscription price $7.90 a year, $2.00 additional for foreign mailing. Price for a single copy of this issue is $2.00.

UNITED STATES GOVERNMENT PRINTING OFFICE
DIVISION OF PUBLIC DOCUMENTS
WASHINGTON, D.C. 20402

OFFICIAL BUSINESS

U.S.MAIL

POSTAGE AND FEES PAID
FOURTH CLASS RATE BOOK
EPA-335

FEDERAL WORKING GROUP ON PEST MANAGEMENT
(RESPONSIBLE TO THE COUNCIL ON ENVIRONMENTAL QUALITY)

Serials Department
Xerox University Microfilms
300 North Zeeb Road
Ann Arbor, MI 48106 EPA 18-2

If you do not desire to continue receiving this publication, please CHECK HERE ☐; cut off this label and return it to the above address. Your name will be removed from the mailing list.